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PHYSIOGRAPHY OF THE REGION TO THE WEST AND SOUTH-WEST OF LAKE RUDOLF

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THE region to be described covers about 27,000 square miles and has during the last thirty years been variously designated. Latterly however, and during the period when the writer was in administrative charge, it was known as the Province of Turkana of the Colony of Kenya after the name of the tribe who inhabit the greater portion. To the east a natural boundary is imposed by Lake Rudolf approximately 180 miles in length and from 15 to 20 in width and by the eastern Rift Valley wall represented by the Samburu Escarpment; to the west by the opposite wall known as the Uganda Escarpment from Zulia to Moroto, thence southward by a purely political and highly controversial line to the northern slopes of Mount Elgon and thence by an approximately east-and-west line along the northern edge of the Trans-Nzoia farmlands through the summits of Tiati and Silali to the Samburu Escarpment; to the north a latitudinal line ruled through the northern shores of the lake to Mount Zulia provides a provisional boundary, ignoring physical features and the racial distribution of the fierce nomadic tribes who inhabit the frontiers of Kenya, Abyssinia, and the Sudan. As far as records go, Count Teleki and Captain, now Admiral, Von Höhnel were the first white men to set foot in these parts, and it was due to them that the lake which they discovered in 1885 received the name of Rudolf after the then Crown Prince of Austria.

Until comparatively recent times it was therefore to Europeans a *terra incognita*, and though falling within the British sphere of influence was still unadministered up to the outbreak of the Great War. It constituted the tribal lands of the pastoral and nomadic Suk and Turkana tribes, a happy hunting ground for slave raiders, cattle thieves, and poachers of big game. It could be entered only by strongly armed parties, for both the Suk and Turkana as well as the adjacent tribes were brave and warlike, and many were armed with rifles obtained as a result of the illicit arms traffic which flourished along the Red Sea littoral during the latter part of the last century and beginning of this. Hence even in 1930 no systematic survey had been undertaken, and such

topographical information as we possessed was based on reports and sketches of certain localities made by civil and military officers. Lieutenant Gimmell, R.E., had during the operations of 1916–17 measured a base at Muruethi on which a number of the more prominent natural features had been triangulated, but difficulty was experienced in bringing these into relation with the more northerly points determined by the Kenya Government Triangulation. In 1899 Major, now General, H. H. Austin, who passed down the western shore of the lake as far as Lodwar and up the Turkwel valley, determined the values of a number of natural features along his route by astronomical observations, and two years later setting out from Uganda he traversed much the same route. Vast areas however remained untouched, and the greatest difficulty was experienced in bringing the work of these various officers into harmony and also in co-ordinating it with points shown on maps produced by the Sudan and Uganda Governments.

The writer therefore determined to undertake a reconnaissance triangulation of the whole area to be built up on the most northerly points determined by the Kenya Survey: Riwa Kwaisagat, Tiati, and Kapchok. During the establishment of the necessary trigonometrical stations the writer collected his specimens, made the notes on which the substance of this paper is based, and the plane-table sketches from which, together with existing material, he was able to compile seven sheets on a uniform scale of 1/250,000, which cover the province of Turkana and a portion of the Southern Sudan. At the time of compilation however the values obtained later from the field observations were not available and the sheets had to be drawn on a graphical triangulation carried out simultaneously with the theodolite observations. These values calculated by the Kenya Survey Department are now in the hands of the Ordnance Survey at Southampton, where the sheets referred to above are being redrawn prior to reproduction. The accompanying map is thus but a compilation carried out in 1930 for administrative purposes, and should only be regarded as a diagram to assist the reader in locating the approximate position of places referred to in the course of this paper. The geological collection has now been presented to the British Museum (Natural History) at South Kensington. Petrological descriptions of the specimens have been prepared by Lieut.-Colonel W. Campbell Smith, M.C., of the Department of Minerals, and these we hope will be published shortly in a separate paper.

Primary divisions

The area under consideration falls into two distinct divisions:

(*a*) The uplands or back-bone of the continent, consisting of the Archaean schists and gneisses with older acid and a few basic intrusions and accompanying granites, the whole being generally spoken of in Africa as the Basement Complex and standing at an altitude of over 4000 feet with a few isolated patches of eruptive rocks mostly on the hill-tops.

(*b*) The lowlands or floor of the great Rift Valley, over the greater portion of which the Archaean rocks are covered by a sheet of Tertiary and even more recent lavas, and standing at an altitude of 4000 feet.

The dividing line is of course the western wall of the Rift Valley, a northern

prolongation of the Elgeyo bifurcation,[1] which continues for nearly 300 miles to Mount Zulia, the tripartite boundary of Kenya, Uganda, and the Sudan. Here it gradually fades into the plains which spread out northwards to the Nile—whilst the general trend of the Rift Valley is deflected in a north-easterly direction and indicated by a series of trough-shaped lakes in south-east Abyssinia. It seems that a distinct wrench in the faulting has occurred, and that this has produced what may be termed "splinters" which follow the original line of fracture until they gradually die out as they get farther from the axial line of the subsidence.

The Highlands

(1) *Effect of deforestation and erosion*

The highlands which attain their extreme height in Sekerr (10,910 feet) may be said to lie at a general altitude of 5000 feet. They are well watered with a rainfall of from 20 to 50 inches per annum, and enjoy an equable climate, not unsuited to European settlement. The vegetation is sub-tropical, and in parts, especially at the higher altitudes and along the river banks, luxuriant. The mountain sides at 6000 feet and above are often clothed in dense forest, with many good timber trees, and at no very distant date much more extensive than at present. The deplorable deforestation which has taken place recently, due in great part to fire, overstocking, and native methods of cultivation, is exercising a serious influence on the physical condition of the whole region. Even if the actual rainfall has not been appreciably diminished, the retention of moisture, the soil cover, the yield of the springs, and the period of flow in the rivers have all been greatly diminished. The predominant quartz sand derived from the weathering of the Archaean rocks results in a soil from which the finer particles containing the potash and alumina are readily separated, a process rendered all the more easy by the absence of a protective vegetation, previously removed by fire, cultivation, and overstocking. The more valuable soil products usually contained in the finer sediments are thus in a state which renders them highly susceptible to transport by wind, water, and gravity to the lower levels and even to the lake. Bare subsoil and sand containing little or no alumina or potash remain, and in fact all the evils attendant upon accelerated erosion are here exhibited in perhaps a more aggravated form than in other parts of Kenya. Whilst in some places pans of heavy clay or "black cotton" soil have formed, in others accumulations of quartz sand give rise to a soil of complete sterility. True the former are eagerly sought by natives for the little cultivation they practise, and under favourable weather conditions such areas it must be admitted do support crops which often come to maturity; but these patches are too limited in extent to supply sufficient cereal food for the needs of the native population, 90 per cent. of which subsist on an exclusive diet of milk and meat.

These two processes combine to bring about conditions which are extremely difficult to combat. The rapidity with which they are operating can only be realized by a tour through the country during the rains when the rivers are carrying down their burden of soil resulting in the formation of extensive deltas and the general silting up of the lake. This paper is not however the

[1] 'The Rift Valleys and geology of East Africa,' Prof. J. W. Gregory, 1921, p. 215.

place for a further development of one of the most serious problems now confronting the Government of Kenya.

(2) *Drainage*

The crustal movements which have given rise to the Rift Valley formation have had a profound influence upon the drainage which in consequence exhibits some peculiar features. In the south-east there occurs one of the most striking watersheds in Kenya. The hill of Kwaisagat may be taken as the crucial point, and the water-parting extends roughly east and west, forming the northern limit of the Trans-Nzoia Plateau and Cherangani Hills. Drainage to the north is by mountain torrents which collect on the plain below in the Suam and Majun rivers which empty into Lake Rudolf, whilst to the south the streams find their way along a more gentle declivity towards the Nzoia River and Victoria Nyanza. The drainage therefore of the whole area with which this paper deals is into Lake Rudolf from which at present there is no outlet and its waters are in consequence becoming alkaline to such a degree that they are now hardly potable.

The most important river system is that of the Suam or Turkwel River, as it is called in its lower reaches. Rising on the northern slopes of Mount Elgon it debouches from the higher regions through a gorge cut in the lavas and tuffs of which the mountain consists. A few miles before reaching Kacheleba and at an altitude of about 4500 feet it leaves the forest-clad slopes and continues across the Suk upland, sometimes taking advantage of the long axes of the troughs between the folds of the Archaean rocks and at others cutting across and through them till at last it finds its way out on to the Turkana plain by a deep and narrow gorge at right angles to the fault planes of the Rift Valley wall. Thence it collects the drainage of the Cherangani Hills and turning northwards and finally eastwards and so by a somewhat meandering course through the plains to the lake. For long stretches the banks are lined with enormous thorn trees and dense undergrowth, the home of tsetse fly and elephant. A glance at the map will suffice to show the extensive area drained by this river, including the vast Karamojong Plain from Elgon to Moroto, a region subject to the most violent tropical storms. On such occasions the Kamyangarang River will rise 20 feet in a few hours, and carrying all before it sweeps through the narrow entrance of the Turkwel gorge in a turbid volume of water over 80 feet deep. Two tributary streams deserve mention: firstly the Majun which rises in the Cherangani Hills (12,000 feet), secondly the Whei-Whei which drains the eastern flanks of the same range and joins the Majun soon after it leaves the Marich Valley by which it finds its way to the plain. The combined waters known as the Malmati offer a perennial contribution to the Turkwel a few miles farther downstream, but even so during the height of the dry season the river at Kaputir, some 10 miles beyond the confluence, is reduced to a narrow channel of shallow water meandering from side to side of its wide sandy bed. During two exceptionally dry seasons (1933–1934) surface water failed even to reach this point.

The Kerio or Ndoo River lies in a parallel trough to the east, and rising in a remarkable cirque near Eldama flows northwards between the Elgeyo

Kacheleba rock: monadnock of gneiss. Suam river in foreground

Mogilla range from south

View up the Turkwel gorge from Lokwien

Onset of desert conditions between Muruarett and Fergusson's Gulf

Lodwar hill from the south

Vegetation on Nepau-Lorugumu road

Escarpment and the Kamasia hills and so past the abandoned station of Kolossia to Lake Rudolf. It is therefore a river of the lowlands and will be mentioned later. From Moroto northwards the Rift wall forms the watershed between the Nile and Rudolf basins. Though two or more large embayments have been formed, partly owing to the existence of transverse faults which temporarily interrupt the continuity of the Rift wall, the eastern rivers have not yet cut back their beds very far to the west of the general line of the escarpment. On the western side the Nile tributaries commence almost on the crest and flow by easy gradients across the Uganda plateau.

Only those rivers which rise in the forest-clad mountains maintain a perennial flow and these dry back towards the source during the hot weather. Others, and it must be admitted the vast majority, fall into this category, though subject to violent periodic flooding, present during the greater part of the year dry sandy beds in which however water is frequently obtained by digging. Favourable spots are known to the natives who sometimes go down to a depth of 30 or more feet in their search for water. Such spots are often determined by the existence of dykes or the strike of some more impervious band of rock across the direction of the flow. With the return of rains the holes of course become filled with sand and have to be reopened as soon as the surface flow ceases.

(3) *Rains*

Breaking usually in March the rains continue till June and resume again in September and October, and at times are torrential, causing widespread erosion of a soil already loosened by prolonged drought and largely denuded of its natural vegetation. The autumn rains, which are uncertain and inclined to be local, are more plentiful in the higher regions, especially in the Cherangani Hills, where records taken at Kapenguria, the provincial headquarters for the last few years, suggest an average rainfall of 50 inches per annum. In the lower altitudes, that is from 3000 to 6000 feet, the average would not exceed 25 inches per annum. With the proper conservation of moisture and due regard to overstocking and grass burning, there is no reason why a great portion of the Suk uplands should not be rendered sufficiently productive to meet the needs of the present native population.

Outside the forest area real springs are not abundant, due probably both to rapid run-off consequent on conditions mentioned above and the high angle at which the schists are often tilted, which from their porous nature allows surface water to percolate to depths from which it cannot readily be recovered for the use of man. Whatever be the true cause of the lack of springs, it would appear from available evidence that many have dried up during the last two or three generations, and that the prospects of augmenting the water supply in the Suk uplands by boring are not very bright.

(4) *Scenery and vegetation*

Undulating plains, granitic tors, and rounded hill sides cut up into a maze of deeply sculptured valleys lend to the highlands a characteristic morphology by which the Archaean areas may readily be recognized. The granites, gneisses, and diorites, being more resistant than the schists, stand out as ridges, crests, and bosses, imparting a unique grandeur to the mountain scenery. Monoliths

of gneiss offering well-defined points for the topographer are not uncommon, and nowhere is to be seen the rigidity of landscape associated with the basic lavas of later age. The vegetation too belongs to the African type known as "savannah," which so often denotes a light rainfall and the presence of Archaean rocks. On the hill sides coarse long grass grows usually in tussocks, due to annual burning, and heavy run-off which has removed the intervening soil leads at lower levels to the formation of storm gullies. Not only is such grass avoided by cattle but harbours the tick which conveys the east coast fever. Hence the natives delight in burning it in the hope of killing the ticks. By doing so they unfortunately destroy other and more valuable grasses. In the plains and valleys the sandy soil washed down from the hills supports a thin light grass which is sweet, and so eagerly is it devoured by stock that by the end of the dry season little or none is left.

The pasture is being seriously threatened by ever-increasing patches of *Aloes*, *Crassula*, and *Euphorbia* which, owing to the protection which this type of vegetation affords against sheet erosion, generally stand on low mounds, thus promoting gully formation. No grass will grow with these plants, and there seems to be no provision in nature for restricting their hardy growth and propagation. Under acacia trees and bushes, on the contrary, grass often thrives, protected no doubt from the trampling and grazing of wild and domestic animals. Experiments carried out in the neighbourhood of Kacheleba confirmed the supposition that great improvement in pasture could be obtained by the prohibition of grazing or passage of stock even if only for a period of two years.

(5) *Geological*

The granites, schists, gneisses, and amphibolites of which the highland area is composed are similar to those found elsewhere in East Africa and do not call for any particular description here. They are well exposed in the cuttings made in the process of road construction, especially on the Suk and Kacheleba Escarpments. In the northern prolongation of the Cherangani Hills through Sekerr and the Chemerongi Hills the rocks have been subjected to heavy stresses and have in consequence been thrown into a complicated series of folds which have since been severely denuded. The axes of these folds lie approximately north and south and the troughs have been much deepened by the corrasive action of rapid-flowing rivers which have thus in many instances converted the septa of folds into parallel lines of cliffs on either side of the valley. Hard bands of gneiss often appear as rocky crests crowning narrow ridges which divide the valleys. In other places they give rise to "monadnocks," as for instance the Kacheleba Rock, of which the domed appearance is due to exfoliation, a type of weathering so common in tropical Africa. A beautifully white marble band outcrops at the head of the Marich Valley and may be traced along the hill side on the left bank till the river turns right-handed and away from the strike. Other bands of marble less pure have been met with elsewhere. Mica occurs in quality and quantity which promises a market should transport costs not prove prohibitive. Asbestos has been found at the foot of the Kacheleba Escarpment not far from an intrusion of hypersthene-olivine-gabbro.

Three, possibly four, transverse faults or groups of faults arranged in echelon appear to cut across the tectonic lines of the Rift fractures and are worthy of note as they have exercised a considerable influence upon the geography. The first forms the northern limit of the Trans-Nzoia and emerges from under the lavas of Elgon in the neighbourhood of the Suam river and continues eastwards in the steep cliff already alluded to under the Trigonometrical Station of Kwaisagat. Thence it coincides with the course of the Majun river down the so-called Marich Pass. The fault plane is not always well defined, but from the summit of Kwaisagat its existence is evident and its significance can be fully appreciated. The general lowering of the country to the north would indicate a down-throw of some 2000 feet.

The next fracture is the one which has given rise to the Turkwel Gorge, and from one aspect it appears that an overfold on a east and west axis has resulted in a fracture which depicts the emergence of the river at the eastern end of the gorge. Though this plane of weakness due to faulting may have determined the course, the formation of the gorge is almost entirely due to the corrasive action of the river. In short, a water fall of perhaps 1000 feet deep, occasioned by the subsidence of the Rift floor, has in the process of time given place to a series of cascades at the bottom of a deep and narrow gorge. The western entrance is almost as imposing, for a highly resistant band of granitoid gneiss which cuts across the course of the river has been deeply notched forming a narrow and almost vertical portal not more than 20 feet in width. This resistant band of rock has had the effect of checking the rate of corrasion so that for some 10 miles or so upstream the rate of flow is much reduced. It has been suggested therefore that this might be an admirable site for a dam. The silt problem would however present grave difficulties, and even if overcome it is more than doubtful if the economic utilization of the water would warrant the expenditure involved.

The gorge is a magnificent spectacle, being about 4 miles in length and of varying width. In many places there are cliffs rising some 300 feet from the water's edge so that passage can only be achieved during exceptional drought. Above the cliffs the sides rise steeply for another 1500 feet, and at this altitude are seldom more than a few hundred yards apart. The aneroid showed a difference of 1000 feet between entrance and exit. The channel is cut down on to the rock and is strewn with enormous granite boulders often over 25 feet in diameter. These have been rounded and smoothened and in places fluted in an unusual way by the sand-laden water. This, with the gigantic scale in which the whole scene is set, gives the impression of the massive stone work of ancient Egypt as one makes one's way through the interstices of these fallen monoliths. Pot-holes 10 to 15 feet in diameter have been formed in the bed, and these as they become larger tend to join up, affording an excellent example of the important part played by pot-holes in the process of corrasion and particularly the gorge formation.

Further north at Lokitanyala some complex faulting dramatically exhibited in the north-east cliff (Sebeg) of Moroto mountain is no doubt to some extent responsible for the Moroto embayment, one of the most striking topographical features of the whole region. Accepting the Muruanisigar cliff as the con-

tinuation of the fracture which south of this point forms the Rift wall, it is 25 to 30 miles deep and about the same distance across. The Munyen river which drains it has its source about 15 miles north of Moroto mountain, and here the Rift scarp striking northwards from the mountain has sunk into comparative insignificance and has been so deeply sculptured by the numerous tributaries of the Munyen as to be hardly recognizable. A few miles farther north no evidence of its existence remains, and in fact a thin but continuous covering of volcanic rock extends from the Uganda plateau to the broken volcanic country lying to the west of Muruanisigar. This volcanic cap stands at an altitude of less than 5000 feet, which is probably the lowest part of the Rift wall. Moroto is essentially a basement complex hill with a volcanic series resting on the summit and apparently tilted westwards; and so also is the fault scarp which reappears just south of Yelele hill and extends with but one break (the Oripowi embayment) for some 80 miles farther north, where it terminates in Mount Zulia, a large intrusive boss of quartz-syenite. The high plateau to the west as observed from Yelele (an ancient intrusion of nepheline-syenite) presents the features associated with the basement complex with occasional dome-shaped hills suggestive of acid plugs. The Oripowi embayment is similar in some respects to that of Moroto, and beyond doubt can only be accounted for by some transverse faulting which has left the crystalline rocks of the Lokolopus mountains standing out some 30 miles from the general alignment of the fault scarp, whilst the country to the north, south, and east has been dropped and now lies covered by a volcanic sheet.

The lavas of Mount Elgon have flowed into the south-west corner of the area and are seen as nepheline-basalt, nephelinite, and phonolites in and about Mount Riwa. The imposing massif of Debasien, lying some 40 miles to the north and really outside the area with which this paper deals, is covered by a thick volcanic sheet which may or may not be a remnant of much larger flows associated with the lavas of Mount Elgon on one side and Moroto on the other. No other eruptive rocks were observed in the upland or highland zone, but Mr. V. G. Glenday[1] reports the existence of some in the Suam valley not far from Maral.

(6) *Native population*

The natives who occupy these more elevated areas are the Pokoot, as they call themselves, but are more generally known as the Suk. They number about 25,000 and extend down into the Rift Valley toward Kolossia. They belong to a group often alluded to as the Half-Hamites and speak an entirely different language from the Turkana who occupy the rest of the area with the exception of the lowland area between Marich and Kolossia. They are really pastoralists, but their mixed origin gives rise to a small percentage practising agriculture. All have a preference for stock, the possession of which is regarded as the sign of wealth and position. They keep cattle, goats, sheep, and donkeys, but not camels, which do not thrive in the highlands. Though by no means to be despised the Suk are not a match in war for their Nilotic neighbours the Turkana and Karamojong. In favourable sites (*e.g.* Whei-

[1] "Geology of Suk Hills (Kenya Colony)," by V. G. Glenday and John Parkinson, *Quarterly Journal of Geological Society*, vol. lxxxii, 1926, p. 614.

Whei) the Suk have made some valiant efforts at irrigation, but the channels having been cut at steep gradients, the water flows with such force over the fields that the soil has been removed, exposing sub-soil and rock which either remain bare or support a pernicious crop of weeds. With proper supervision and the expenditure of comparatively small sums of money however great improvement in agriculture could be effected, and the younger generation of the native population have already shown themselves not unresponsive to the agricultural stimulus which Government has already offered.

The Lowlands or Floor of the Rift Valley

(1) *Extent and general description*

It is in this area that perhaps the greatest interest lies and but little geographical information seems to be on record. From the foot of the Rift wall which stands at an altitude of from 2500 to 3000 feet the plain slopes gradually to the lake which is now calculated to stand at 1230 feet above sea-level. The mean distance to the shore may be considered as 90 miles, so that the mean gradient is 19·7 feet in a mile. Mountain torrents from the highlands therefore receive a very appreciable check, and this has resulted in huge accumulations of the coarser sediments mixed with other detrital material forming fan deltas along the foot. While the larger rivers have cut fairly deep, many of the smaller streams spread over the plain or flow in ill-defined and shifting channels. Such streams flow for but a few hours after heavy rain has fallen on the highlands, and so great is the absorption in the plain that many end in accumulations of sediment and other flood products resulting in the formation of earth pans, which support the exiguous cultivation which the Turkana occasionally practise. In these also a little seasonal grass appears, but is soon eaten off by the stock who trample the baked mud into dust which is carried in swirling columns across the plain. It is only the larger rivers, which flow for several weeks at a time, that succeed in carrying their finer sediments to the lake where the mouth becomes blocked as the flood subsides. This accumulation is pushed farther out into the lake by subsequent flooding, and thus the extensive deltas already referred to have come into existence. The beds of such rivers are filled with quartz sand often to a depth of 20 feet or more and are frequently contained between cliffs of previously deposited delta material. This affords further evidence of the shrinking of the lake which at no very distant date must have extended westwards almost if not quite up to the foot of the Rift Escarpment. The plains may therefore be regarded as an area peneplaned after the formation of the Rift Valley and now covered by lacustrine deposits derived from the denudation of the uplands and mountain features whose remnants rise to-day out of the plain almost as conspicuous as they must have stood in former times as islands in the Greater Lake.

(2) *Drainage*

This necessarily follows the tilt of the lacustrine plain along lines of least resistance to the lake, the direction being influenced by the position of the mountain features. With the exception of one or two mountain streamlets on the west side of Muruanisigar none of the rivers maintain a permanent

flow: in fact, in few except the Turkwel, the Kerio, and the Kaburiouri does any surface water pass for more than a few days after rain, though water may be found for a further period of two or three months by digging. The Kaburiouri rises in the dense forest at the summit of Muruanisigar and is joined by several others, some of which may claim a permanent trickle near their source. It is from this river and its tributaries that the Tarash draws most of its early supplies which during rains are often so copious as to cause extensive flooding of the broad plains which surround Kakuma. From Lokiriama downstream the river flows through a wide and open plain where the channel is sometimes ill defined and there exist evidences of recent alteration of course. Below the abandoned station of Kakuma which stands on a low hill on the right bank it breaks into two, but joins again before it finally empties its waters on to that enormous sand plain so erroneously called the Lotogipi swamp. This, except during heavy rains, is an extensive earth pan some 60 miles wide and 70 or 80 miles long. Rivers from the east, west, and south drain into it. It has no visible outlet in the north, but it is more than probable, judging from observations taken from the summit of Mount Kaitherin, that during exceptional flood it could and probably does drain north-eastwards into the Ngalabalab swamp and so into the Kibish, which empties into Sandersons Gulf. A rise of 300 feet in the Lake Rudolf level would flood the Lotogipi swamp, and it is likely that at no very remote period the two were parts of a single sheet of water. The Lotogipi has in fact dried up in historic times whilst Sandersons Gulf has dried up in our own times. Biological evidence suggests that Lake Rudolf was at one time part of the Nile basin, and to this there is no objection on topographical grounds, for it is but a comparatively insignificant undulation that separates the Lotogipi from the affluents of the Nile.

(3) *Lake Rudolf*

Observations indicate that during the last thirty-five years the level of the lake has been steadily sinking, and in the last five years at a rate of no less than 1 foot in a year. The total drop during the last twenty-five years, calculated from maps and observations made by General H. H. Austin, may on a conservative estimate be placed at 25 feet. Evidence of this may be found in the drying up of many gulfs and inlets, the most striking example being Sandersons at the north-west corner, which was mapped in 1900 as 30 miles long and 8 miles wide with a sound 3 miles or more broad connecting it with the main water. The gulf is now completely dry and the sound is blocked by sand dunes. In 1902 Count Bourg de Bozas described a bone bed at what was then mouth of the Omo and set up some landmarks; in 1933 M. C. Arembourg informed the writer that he had identified them and that they were now 20 miles or more from the present mouth. Old lake beaches have been found by Dr. Worthington up to 400 feet above present level, and many by the writer at up to 300 feet especially round the southern shores of the lake, where the hills drop steeply to the water.

(4) *Desert conditions, rain and vegetation*

This recession of the waters has left behind vast stretches of fine sand which is now being blown back over the land by an almost constant south-

easterly wind, covering a great part of the plain with shifting sand-dunes. The drought of 1932–34 so accentuated these conditions that many parts of Turkana which only five years ago were passable grazing can only be described now as desert. The wind is very persistent and for several months in the year blows from sundown till noon, often increasing to gale force, lifting the dust high into the air and carrying it to great distances. Wind from the opposite quarter is infrequent and of an intensity quite insufficient to have any appreciable effect on soil transportation. These conditions can only be relieved by prolonged and general rains over the whole area. It is gratifying to receive news that in 1936 more rain has fallen in Lodwar than during the previous four years put together.

A further evil attendant upon the recession of the lake is a corresponding drop in the water-table, which causes the death of even those few trees which have not been already choked by wind-blown sand. South of Fergusson's gulf thousands of thorn trees stand like a ghostly army, with their grey gaunt limbs extended to the sky until one day they fall before the wind and the white ants complete the work of destruction, a striking example of the ruthless hand of nature. The western lake-shore and the basin of the Turkwel are the areas most seriously affected. In the Saguta valley desert conditions are now complete, for the lake which once existed there has dried up to a small swamp at the northern end. It may be regarded as a minor example of the final stages of what is now taking place on a much larger scale round Lake Rudolf.

Nor is it the lacustrine plain only which is suffering this desert change, for on the more elevated areas, especially the large basaltic plateaux which are a common feature of the landscape to the south of Lodwar, such little soil as is derived from the weathering of the basalt is blown off into more sheltered spots, leaving behind a sea of rust-red boulders over which it is most difficult if not dangerous for man or beast to walk. Farther from the lake shingle deserts are more general, and over large tracts motor vehicles can be driven with little or no preparation of the surface. Occasionally sheets of calcrete travertine and other deposits, which under certain climatic conditions form in the subsoil, have been exposed where short erosion has removed the overlying soil.

With an adequate rainfall many parts of the plains would undoubtedly be productive, for though the soil components are badly distributed they are there, and by the application of suitable methods could be combined. Near the lake the excess of alkali would offer difficulties, and only certain types of vegetation, unfortunately generally useless to human beings, will grow. Even on the hill sides grass does not grow readily and for years has been insufficient for the livestock possessed by the tribe, 75 per cent. of which died off during the three years of drought. Along the river banks and in corries in the hills there are many more and a greater variety of trees than one would expect, but great expanses of the plains are entirely devoid of vegetation. The large majority of the trees belong to the thorny acacia type which along the banks of the Turkwel, Kerio, and a few other rivers grow to an immense height and are sometimes surrounded with a belt of quite dense undergrowth. Several varieties of *Euphorbia* are common, some of which are formidably

armed. One tree or shrub seems to be particularly adapted to resist the rigours of the desert and is easily recognized by its bright green foliage. To the Swahili-speaking natives it is known as *Mswaki*, and not only provides them with excellent tooth brushes but furnishes grazing for camels. Another, called by the Turkana *Adome*, the timber of which is used for many domestic purposes, bears a yellow berry which in spite of its waxy consistency and, to European palates, unpleasant taste, is eaten with relish by the Turkana and must have saved many a hungry traveller from death. A botanical collection was made and has been presented to Kew, where no doubt it is readily available to those who may be interested.

The rainfall as recorded in Lodwar for the years 1931 to 1934 was under 2 inches per annum; this is however much below the average for the previous eight years which was between 4 or 5 inches. The Government station is admittedly situated in a dry belt, and though records at Kaputir to the south and Lokitaung to the north have only been taken for a few years, there are indications that an annual average of 12 inches may be expected at the former and 15 inches at the latter. The range of temperature is not great, the thermometer seldom rising above 108° or below 80° shade temperatures. The southern area, south of the Turkwel, is subject to the same monsoon influences as the highlands, and the rains occur at very much the same seasons but less plentifully. In the northern area, including Kaitherin, Lorienatom, and Labur, the seasons would seem to come under a different influence and the rains break in February or March in the form of violent atmospheric disturbances in the Omo Valley, resulting in heavy rainstorms often of a local character. On one occasion 6 inches of rain fell in an afternoon at Lokitaung, and the hill sides were stripped of soil and vegetation. Throughout the length of the Rift scarp from Moroto to Zulia during the monsoon rain falls regularly, and this accounts for the striking difference in the vegetation on the Uganda Plateau and the sun-scorched arid plains of Turkana. Muruanisigar Range, standing 4000 feet above the plain and across the path of the monsoon, induces a precipitation which causes the main catchment area of the Tarash River to be one of the best watered in the whole of Turkana. Here are collected the bulk of the cattle possessed by several sections of the tribe. With the exception of the Kaitherin and Lorienatom ranges, the rest of the country suffers permanently from insufficient rainfall and is only too often in the throes of drought. Even in the most arid and desolate regions however a shower of rain has a magic effect; after three or four days a film of green appears, but close examination shows it to be mostly weeds and other herbs, with almost no grass. The seeds of the latter are rare in the soil because wherever shoots of grass appear they are grazed off by the hungry stock before they even come to flower. And the continual movement of the sand under the influence of wind in those areas already alluded to renders germination and the first stages of growth extremely precarious.

(5) *Dune formation*

In the event of a return to what we can only suppose are normal rain conditions it will be interesting to observe what recuperative power these plants may possess, and whether the shifting sand-dunes can be stabilized. Our

attempts to hold up the drift of sand near the lake shore, where some small areas were put under cultivation, by erecting screens of palm leaves, proved of no avail; the obstructions caused the sand to behave in a very curious manner, often ending in the formation of dunes, which slowly advanced across the very area we had hoped to protect. A fascinating problem was presented to which unfortunately we had neither time nor money to devote. The question naturally presents itself "Is such a region worth saving at such a cost?"

From accounts of travellers such as General Austin and the officers who took part in the operations eighteen years ago it would seem that a marked change has taken place, and one is tempted to think that this can only have been brought about by a steady diminution of annual rainfall and not merely the result of a few lean years. These pioneers speak of grass over the knees, and the long treks across the country accompanied by cattle for which water was obtained daily without any particular difficulty. In those days stock, especially cattle, were evidently more plentiful than in recent years, and no doubt it is to this accumulation of stock, far in excess of the numbers the country could carry, that one must attribute some of the present evils. After such a prolonged period of drought and famine, from which many thousands of natives died and the stock was probably reduced by 70 per cent., one must try not to be too pessimistic, but at the same time it is difficult after four years' residence in the country to see how any lasting recovery can take place without the active intervention of man and the removal of the inhabitants and their stock to some other part of the colony for a period of several years.

(6) *Water supply*

From the foregoing it will be readily appreciated that water supply for both man and beast is a matter of great concern, and many of the springs and water-holes, never very abundant, are now showing signs of exhaustion. In the kloofs or corries of the mountain sides down which the water dashes for a few hours after rain there exist here and there rock pools sometimes of considerable size. These are generally sweet, but the springs are more often than not too alkaline for human use. These latter frequently occur at the foot of mountain ranges in connection with intercalcated deposits of sedimentary tuff or earth. A line of such springs skirts the eastern foot of the Zingout–Mogilla range, where their presence is revealed by small patches of bright green grass of a sort peculiar to alkaline soil. Water obtained by digging in the sandy beds of rivers is invariably sweet. The most abundant supplies of fresh but slightly mineralized water are obtained from the wells at the military post of Lokitaung which suffices a population of a thousand or more, and in the Murueris Hills.

(7) *Geological structure of the plains*

The south-western portion of the floor of the Rift Valley is composed of the Archaean holocrystalline rocks which may at one time have been covered wholly or partially by volcanic debris. In any case, at the present day there is little evidence on which to form any definite opinion. North and east of a line from the foot of Muruanisigar, Muruethe, Emurualigui, Kailongol, and Kolossia, the volcanic covering is complete and the basement complex is only revealed outcropping in cliffs such as Labur, Kaureta-Authrui, Mugir,

and the cliffs at the south-west corner of Lake Rudolf, and as real inliers in parts of the Kerio Valley. It must be remembered of course that as the crustal rock is often covered by extensive alluvial deposits, it is difficult to determine the character of the solid geology. Petrologically the crystalline rocks are in no way different from those of the highlands described above, and inselbergs and monadnocks such as Naitai Obelisk, Oterrkos Needle, Morochorod, Lokopel, Baraich, Emurualigui, Nakapelachom, and Kariamathe are of common occurrence. This similarity affords additional evidence of the structural character claimed for the Rift Valley. On the eastern side of Sekerr the escarpment is perhaps at its maximum height and is only equalled in grandeur by that of Elgeyo. This wall of rock extends northwards with but two narrow openings which allow the Suam and Kateruk rivers to emerge from the Suk uplands until at Lokwamur it is interrupted by the transverse faulting giving rise to the Moroto embayment already described. It then re-establishes itself in the formidable line of cliffs extending from Muruanisigar through Pelekech, probably reappearing along the eastern side of Kaitherin. The outer or more westerly fracture from Moroto northwards has already been dealt with.

The volcanic rocks are generally found resting on the eroded surface of the basement complex and vary considerably in age, composition, and thickness. Generally speaking, phonolites of the Kenya type occupy the area between Kolossia and Loperot and are perhaps the oldest in the magmatic series; basalts and basanites form the Loriyu plateau and the western side of the lake, whilst farther again to the west and up to the Uganda Escarpment more acid types such as rhyolites and trachytes predominate. They would appear, from the position in which they are generally found and from other geological evidence, to be the result of more recent eruptions, quite distinct however from the modern or post-Rift lava flows occurring at the south end of the lake which have reverted to a more basic composition.

Other fault scarps occur along the south-west shores of Lake Rudolf, the Mugir Valley, the cliff from Loperot to Kaureta-Authrui, Sugota Valley, and Labur, all in conformity with the tectonics of the Rift Valley. In all these as in Muruanisigar the volcanic rocks have been faulted with those that underlie them; the conclusion may therefore be drawn that these gigantic outpourings of magma took place before the rifting process occurred. This however must not be taken to imply that the process did not continue later, for in fact it survives to the present day, as was evidenced in 1928, when a subsidence of several feet took place to the north of lake Solai but a few miles south of the area under consideration and was verified by the writer only a few months after it had occurred.

Eruptions of lava have also taken place since subsidence commenced, but apparently on a much smaller scale, *e.g.* the barrier at the southern end of the lake and the northern portion of the Katigithigir Range. There occurs however in the cliff of Labur, the plains to the south and south-west of Kosekria, in the neighbourhood of Muruarett, and on the Kalabata River (10 miles west of Loperot), a series of grits and felspathic sandstones almost entirely derived from the crystalline rocks and from 100 to 800 feet thick. They have been found resting unconformably upon the basement complex,

but these well-developed planes of stratification are generally conformable to the structural or flow planes of the overlying lava. Their deposition would appear to have taken place prior to the initial outpourings of lava and is thus independent of the Rift Valley formation which occurred at an even later date. Little or no volcanic material is found in their composition. They do not occur in the south or west of the area. Organic remains found up to date have been quite insufficient on which to establish the age or origin of these rocks which remain somewhat obscure, and the name (Turkana Grits) under which they were first recorded by Mr. H. L. Sikes, the Director of Public Works, has been preserved.

Superficial deposits of concretionary limestone (Kaputir Hill) calcrete, which forms at a depth of 2 or 3 feet below the surface under certain desert conditions, and laterite also occur in places. The lacustrine deposits now occupying the plain may be generally regarded as of Pleistocene Age.

(8) *Mountain ranges of the Rift floor*

From the general level of the plains there rise no less than ten distinct mountain features, two or three of which had not figured on the maps until a few years ago.

(i) The Central Range, Laiteruk, Kailongol, Kemeruk, and Emurualigui, may be taken first as it consists entirely of the schists and gneisses of the basement complex. The summit of Kailongol attains a height of 6800 feet. Though possibly the range represents a step in the series of faults which go to make up the western Rift wall, severe denudation and the removal of any cap of volcanic rocks which it may formerly have had have given to the whole range the appearance of a series of residual hills. They form a very effective watershed between the Turkwel and Kerio rivers, and north of Loperot between that river and the Lomenyangaparat. They are riddled by igneous intrusions of acidic type which are responsible for the crests and tors which are such a general feature. These igneous dykes appear like Roman walls stretching across the mountains and at points of intersection often give rise to bold and rocky summits, Changamalak being a striking example.

(ii) The Loriyu Plateau is a basaltic sheet stretching from Gautoro southwards some 100 miles to Taita, where it appears to connect with similar flat-topped lava hills in the neighbourhood of Baringo. It varies in width from 15 to 25 miles, and its general shape suggests that it is a stream of lava which followed a river valley the sides of which have now been removed by erosion leaving the harder lava standing up as a tableland after the same manner as the Yatta Plateau in the Kamba country farther south. The focus of eruption may have been the collection of hills known severally to the Turkana as Kalojoputh, Makuringa, and Nakapegateng. These appear however to be built up of more acid forms of lava such as rhyolites and trachytes. The lava cap is slightly tilted to the south-west which enables the basement complex to be revealed on the surface at the northern end of the plateau. The surface is strewn with rust-brown boulders devoid of soil or vegetation and swept by a hot persistent and sand-laden wind that renders travel and even existence an almost intolerable burden.

(iii) Westwards across the Kerio lies the volcanic range of Katigithigir

terminating northwards in the domes of Napedett and fading away southwards along the fault scarp to Loperot. Only one visit was made to establish a trigonometrical station at Kaureta-Authrui, and beyond taking the necessary observations and a hasty topographical sketch of the range, which had not figured on previous maps, little was added to our geographical knowledge of the area. The rocks collected have been identified as nephelinites and nepheline basalts and rest directly on the basement complex, which as stated above is exposed in the cliff below the trigonometrical station. The line of the cliff is continued south of the Kalabata river by a number of very conspicuous conical-shaped hills. These are evidently necks or vents which were filled with basic magma now appearing as dome-shaped summits often exhibiting columnar structure. These columns of lava have evidently proved effective points of resistance to the agencies of denudation (*e.g.* Kaipet and Muruagippi). Northwards the cliff is lost in a confused mass of dark and more recent looking lavas which appear to have been extruded from a number of vents, now represented by similar dome-shaped plugs.

From the summit of Kaureta-Authrui a good view is obtained of the watershed dividing the Kalabata from the Lomenyangaparat. The latter is seen to rise amongst a series of gently tilted lava plateaux each presenting a cliff on the eastern side with a dip slope to the west. One is at first tempted to conclude that they represent a number of step faults, in fact a series of small fractures connected with the rift formation. It is however more probable that this physiography is due to the corrasive action of subsequent streams. These now form the head-waters of the river whose course here coincides with the western limit of the volcanic rocks till farther north it forces a passage between the Napedett and Katigithigir ranges and passing under the Lothagam hills finds its way into the lake. From their appearance and position these hills would seem to be a part of the same range and are undoubtedly of volcanic origin.

(iv) The Lodwar mountains may be said to consist of two groups of hills known as Marangapoi and Losidok. Though composed entirely of volcanic material of a basic nature the structural composition of these hills is a matter of controversy. Lodwar station, the site of which was selected fifteen years ago as it commanded a permanent water supply obtained in dry weather from the sandy bed of the Turkwel River, stands on a low round hill consisting of a trachytoid phonolite. It probably represents the summit of a hill surrounded and almost buried by the wind-blown sand referred to above. The conspicuous cone-shaped hill some 800 feet above the plain and generally spoken of nowadays as Lodwar Hill, is the highest point in the Marangapoi Hills which are composed of nephelinite. The hills are almost devoid of soil or vegetation and present a sombre and forbidding appearance very similar to the range described in the foregoing paragraph. Several of the re-entrant valleys have been smothered in wind-blown sand. From the point in the plain about 15 miles west of Lodwar the underlying basement complex is exposed and remains so right up to the foothills of Muruanisigar and the head-waters of the Munyen River. The Losidok group was only examined along its eastern foot and is thought to consist of basaltic rocks of a similar type to those of Marangapoi. This region was thoroughly

studied by Dr. V. E. Fuchs, and also by M. C. Arembourg, and no doubt the result of their researches will be published shortly.

(v) Proceeding northwards across the foot of the Kagwalas river, the glistening whiteness of the desert announces that the outcrop of the Turkana grits has been reached, and as the road ascends the low saddle which separates the Kagwalas and Kalapatasi basins, the volcanic group of hills known as Muruanachok is passed on the left and the somewhat detached hill of Kosekria on the right marks the crest. The former is riddled with a number of dykes which stand out in a remarkable manner and extend far out on to the plain. The highest point of the saddle is composed of an unusual type of green phonolite, and this sheet of lava has been penetrated by an intrusion of microfayalite which now stands up forming the hill of Kosekria. This hill is of no particular geographical importance, but the fact that it was visible from several stations lying to the south and has an easily recognizable summit caused it to be selected as a trigonometrical station. It proved a very useful point in connecting the triangulation of the country to the north, which from this point begins to fall away, with that lying to the south. The road continues through the most desolate country, consisting mostly of trachytes and basalts, and after skirting the western slopes of Murueris, estimated at some 4500 feet above sea-level, turns eastwards through Kalin to Lokitaung. Murueris was not explored but appears to consist of trachyte and possibly some sheets and plugs of rhyolite on its western flanks.

(vi) Labur Range. This range has been better explored than many others as the Military Station of Lokitaung lies on its south-western flank, where a group of permanent springs occurs at the head of the gorge, down which flows the river of the same name. The formation of the gorge is probably due to the capture of a previous tributary of the Dangari River which must have materially increased the volume of water and correspondingly increased its corrasive power. The river takes an obsequent course cutting across the structural planes of the basalt and the bedding of the Turkana grits, both of which are penetrated by basic dykes. These have proved great obstacles to the construction of a motor track down the gorge, which owing to the precipitous sides has frequently to follow the river-bed. The range is about 30 miles long and 8 to 10 wide, and in common with others of the plains presents a steep cliff on the eastern whilst the western side is in the nature of a dip slope of about 10°. The conical summit which stands on the edge of the cliff and reaches an altitude of 4230 feet is a plug of the same black basalt, surrounded by tuffs and other volcanic debris. The cliff is formed of sedimentary deposits of undetermined age referred to above. These rest directly on the basement complex which is exposed at the foot of the cliff and the northern extremity of the range.

Cavendish, who in 1899 traversed the mountain, states that Labur is a volcano and that he found a crater near the summit of which he submits a photograph.[1] Careful investigation has however failed to reveal the presence of a crater and nothing of the kind is visible from the summit. It is however quite possible that there were other centres of eruption, for on the north-western slopes considerable masses of red tuff occur especially at Taban,

[1] *Geogr. J.* 11 (1898) 372–96.

but no evidence of recent volcanic activity has been observed. Pleistocene deposits occur in the lower reaches of the Lomogol River. Between the mountains and the lake an ever-widening alluvial plain has been left as the water recedes. This is strewn with the remains of fish, saurians, and mammals, and suggests a profitable area for research into the Tertiary palaeontology of the area. The plain is however being rapidly covered by advancing sand-dunes.

(vii) Kaitherin and Lorienatom are two massifs which may conveniently be taken together. Both present long lines of double, and in some places, treble-banked cliffs forming their eastern flanks, whilst the western slopes are more gentle. The former with Lokwanamuir, which is part of the same physical feature, is approximately 50 miles long and 15 wide, the latter 25 long and not much less wide. Both are composed of immensely thick sheets of rhyolite and attain a height of over 5000 feet. The former is probably a continuation of the Muruanisigar–Pelekech fracture, and though there exists a gap of some 30 miles between the northern end of one and the southern end of the other, there is geological evidence to support the theory. Beyond, in the region to the north, the fault seems to have completely died out. At Naramum a curious drainage feature not very uncommon to rhyolitic hills was observed; that of subsequent streams flowing in opposite directions along a fault block (*i.e.* parallel to the fault plane), taking an obsequent course on uniting, and bursting through the fault scarp by a deep and narrow defile. In this case the defile contains a rock pool of such dimensions that the supply is regarded as inexhaustible, though there is no evidence of a spring. Advantage has been taken of this to establish a signal station on the bluff above. On the track which climbs the eastern side of Kamathia Hill a forest had evidently been overwhelmed and buried in red tuff, for great quantities of silicified tree trunks and branches had been weathered out and were lying on all sides. They are unfortunately of a genus of tree which flourished in both Cretaceous and Tertiary ages, so that no further indication of the date of the rhyolites is afforded than was already known.

The situation on the frontier rendered it unwise to explore on Lorienatom except with a military escort, so that little or nothing is known beyond the fact that it consists of a confused mass of volcanic debris severely sculptured into sharp ridges and deep gullies with a number of rocky bosses and domes. These appear to be the plugs of vents through which the material composing this massive pile was discharged. Both ranges carry more vegetation than the basaltic ones to the south, but this may be due as much to a heavier rainfall as to fertility of soil. On Lorienatom there are several large patches of forest, and a civil officer who accompanied a patrol reported the presence of rhinoceros, greater kudu, and even signs of elephant.

(viii) Muruanisigar and Puch-Prazir. This area is extremely complex, being made up of a series of fault scarps and dip slopes with the result that the country may be likened to a series of waves breaking on a sandy shore. Survey work was rendered difficult not only by the close nature of the bush and broken character of the country, but also by the attitude of the natives who, though not actively hostile, evidently resented our intrusion, which meant that guides were difficult to obtain and water though not actually

Loriyu plateau, with the craters of Southern Island, and cliffs of basement complex dipping under lava cap on left

Sekerr and the Majun valley. Typical basement complex morphology

Muruanisigar-Pelekech fault-scarp, looking south from Kamerongore

scarce was not always easy to find. The area is best approached by the Kalolokwel River along a donkey track to Lokiriama, a post for some time occupied during the operations of 1915–1916. On the left, as the track enters the foothills, a plateau consisting partially if not wholly of tephrite and bounded on the south by formidable cliffs, occupies the region at the foot of the Puch Escarpment. At its southern end stands the conspicuous feature of Kapel Dome, which resembles a gneissic monolith or monadnock, but has been proved by Mr. Fuchs to be an acid plug of granitic rock. Farther to the west the escarpment of Puch over 2500 feet high, with an extensive plateau lying behind it, constitutes one of the principal topographical features of the area. It consists of red and purple rhyolites which exhibit most wonderful colouring, especially after rain, and under these most probably lies the tephrite. The foot is encumbered with fault blocks like a flight of steps, and the valleys are covered with a thick detrital mantle which renders it difficult to determine with accuracy the nature of the underlying rocks. Here again the peculiar drainage mentioned in connection with Kaitherin mountains was noticed, whereby the mountain torrents escape through narrow defiles on to the open plains. The northern end of the escarpment continues into a saddle which forms the watershed between the Kalolokwel and Tarash basins and links up Puch–Prazir with the massif of Muruanisigar. On this saddle stands the cone-shaped hill of Kwaereria, estimated at 6500 feet. Its shape, and that of several adjacent hills, suggest that they are the plugs of the vents through which were discharged the rhyolitic and trachytic products which are the principal rock components of this mountain area.

The summit of Muruanisigar is clothed in dense forest in which flourish juniper, podocarpus, and olive trees, protea bushes, and a general flora characteristic of the mountain regions of Kenya. Several streams issuing from the west side of the mountain maintain a permanent though small flow of water. Rhyolites or quartz trachytes occupy the upper portion of the mountain and are thought to rest on tephrite which is exposed in the form of cliffs some 2000 feet lower in the Chukulukong valley. These volcanic sheets are however so heavily tilted to the west that the basement complex is not exposed, in spite of the extremely deep ravines and gullies which characterize the north-west slopes of the mountain; in fact they have not been discovered on the surface until the foot of the Uganda Escarpment is reached. In the eastern wall of Muruanisigar the basement complex must attain a height of 5500 feet or more, but drops suddenly on the south side by what appears to be a series of transverse faults, and to the north appears in a projecting line of foothills some 15 miles in length along the escarpment which carries on through Kamerongore to Pelekech and consists throughout as far as investigations go of trachytes and rhyolites. It is evident that the great mass of volcanic rock which covers Puch and Muruanisigar was in existence before this great rift fracture occurred. At the northern end of Pelekech the cliffs are terminated by a series of steps which lowers them to the plains, and they do not reappear again for 30 miles or more, when as mentioned above the fracture may be continued along the eastern face of Kaitherin.

To return to Lokiriama, which rests on a long bluff of purple-banded

rhyolite similar to those found in the Kaliou Pass through which the track to Kakuma has been taken, the country to the north opens out into the wide-open flood-plain of the Tarash extending for 50 miles to Kakuma. Where the underlying rocks come to the surface they are trachytes and impart a strangely depressing and desolate aspect to the landscape: round and shapeless mounds of decomposing rock of a dull neutral tone, giving rise to gravel and muddy soil which seems incapable of supporting more than the most dejected-looking bush and thorn scrub. In the neighbourhood of Kakuma, which stands on a low hill situated on the right bank of the river, the rock is of a similar type and from the decomposed pockets is obtained a green wash which gives an attractive touch of colour to the local buildings. The valley is liable to extreme flooding when great quantities of sediment are transported to the Lotogipi swamp which is now an enormous dry earth plain and from which there is no outlet.

(ix) Zingout and Mogilla. Though separated by the Nanaam River these two ranges are in reality part of the same physical feature. They do not seem to have any connection structurally with the Rift Valley tectonics, and in fact, more especially in the case of the latter, there would seem to be evidence to support considerable faulting on the west side whilst the eastern side is represented by a dip slope. Both are built up of huge accumulations of trachyte and rhyolite and associated tuffs, which would appear to be resting on basalt exposed in the plain at the eastern foot of and possibly western side of Zulia. Along the eastern foot of both groups extends a line of alkaline springs characterised by a growth of bright green grass. The presence of these springs has been referred to as indicating the existence of intervolcanic deposits which outcrop here and there from under a thin covering of detrital material as travertine and coarse conglomerates.

Nathei, which is the highest point in the southern half of the Mogilla Mountains, attains 4500 feet and takes the form of a curious overhanging crescent-shaped cliff of red trachyte fantastically weathered and underlain by brick-red tuffs. One horn of the crescent projects like a fortress wall, and as if to heighten the likeness has been pierced by a window several feet in diameter, visible from below but only accessible to an expert climber. From the summit, easily scaled from the eastern side, a remarkable view of the Lotogipi flood-plain is obtained and an impression may be gained of the enormous absorptive capacity of so vast an extent of alluvium. Few of the rivers which drain into it are of sufficient volume to maintain channels for more than 6 or 8 miles from the foot of the hills when they terminate in small patches of vegetation. With exceptional visibility at dawn or sunset the Kaitherin and even Labur Hills can be seen, but as a rule the great brown plain shimmering in the heat passes through mirage into a horizon of haze and dust.

In 1931, after unusually heavy rains, the R.A.F. officers who flew from Kapoeta in the Southern Sudan to Lokitaung reported a sheet of water at the northern extremity of the Lotogipi. Its existence has however never been reported since. Westwards an alluvial plain lightly covered with grass and scrub extends to the foot of the Uganda Escarpment where a belt of dense bush extends southwards for 40 miles and is inhabited by elephant, lion,

rhinoceros, buffalo, and other big game. Exposures of rock were few but indicated the presence of basalt which, just as the belt of bush is approached near the hill of Kortieng, thins out and allows the basement complex to come to the surface.

Owing to the difficulty of identifying the summit of Zulia, the hill of Kortieng, which consists of trachytoid phonolite, was selected for a trigonometrical station. Schists penetrated by a number of dykes extend a long way up the eastern face of Zulia, but from the huge boulders lying at the foot and evidently fallen from above, the upper portion of the hill must be a huge intrusive mass of quartz-syenite. Northwards the country falls away gradually to the Lomayen River in gentle undulations covered with that type of vegetation indicative of the presence of the older crystalline rocks. To the south lies the broad plain occupied by the Nanaam River and its tributaries which rise in the Lokolopus Hills, that project from the Uganda Escarpment as if in an endeavour to reach Zingout. A peak at their extremity known as Lokalaleu was selected as a trigonometrical station, but was not easy to pick up from the south. As already mentioned, this spur, which consists of gneisses, schist, and crystalline limestone, offers an interesting problem to the student of Rift Valley tectonics. Hereabouts biotite has been found in crystals of possibly commercial size.

(9) *Modern volcanic activity*

The only theatre of really modern and even present volcanicity is at the southern end of Lake Rudolf, and has already been described by the writer (*Geogr. J.* 85 (1935) 323–41). Here a barrier of comparatively recent volcanic ejecta has been thrown up in the formation of a crater which probably featured as an island in the lake when it stood at a higher level. In the course of time accumulations of volcanic debris effected a junction with the shore on both sides, thus cutting the lake in two. The southern portion, owing to lack of feeder streams and evaporation, has dried up except for a seasonal swamp at the termination of the Saguta River, which is itself only kept flowing by supplies derived from the Logippi geyser. On either side of the barrier are two volcanoes, that of Teleki and Andrew or Likaiyu, both of which have erupted during the last fifteen or twenty years, and the resulting lava streams are all basaltic. Steam jets are to be seen on all sides and the topography is too recent to carry soil or vegetation. The existing islands in the lake are all of volcanic origin.

(10) *Native population*

The lowlands are occupied only by the Turkana, a Nilotic pastoral nomadic tribe, who are really a collection of similar ethnic groups, each controlled by a leader or group of elders. Some 70,000 in number, they claim descent from a small tribe called the Jiye, now consisting of only a few hundred souls and inhabiting the Oripowi Valley. It is only during the last century that the Turkana have spread south-westwards over the plains, impelled by increase in stock and human beings. During this movement they came in contact with the Samburu and Rendile from whom they obtained camels for the first time. The men are of large stature but spare, and go completely naked except

for a few ornaments. They carry long spears, fighting sticks, and a small two-legged wooden stool which may be used alternatively as a pillow. The women wear skins decorated with cowrie shells and beads, look after the donkeys, the water supply, and the small amount of cultivation in which a few of the poorer members indulge. Camels are used for meat and milk but never for transport.

In conclusion the writer wishes to thank those who have helped with information and sketches, and especially Messrs. Martin Johnson, David Buxton, J. H. Baker Beal, E. J. Windley, N. Kennaway, R. C. Wakefield, and Captain de la Kirk for photographs to be used in illustrating this paper.

The sketch-map illustrating this paper is to be considered as a diagram rather than as a map. It has been prepared from a copy of the index sheet to the series of topographical maps on the scale of 1/250,000 made by the author. The diagram has been made to relate the lines of faults and the zones of contacts between lats. 1° and 5° N. (as shown on the index sheet) to the names of the features described. No attempt has been made to reproduce the very detailed topography of Mr. Champion's maps.—ED. *G.J.*

THE CORAL ISLANDS AND ASSOCIATED FEATURES OF THE GREAT BARRIER REEFS: *Continuation of a paper read at the Afternoon Meeting of the Society on 7 December 1936, by*

J. A. STEERS

9. The Low Wooded Islands

(*a*) *Introductory*

A physiographical investigation of this type of island was the chief object of the expedition. In 1928 the geographical section visited several of these islands and formed certain opinions about their structure. As the main biological party spent a year on one of them, Low Isles, they have become of general interest. In 1928–29 Spender was able to map Low Isles on a large scale with great accuracy, and his map will remain a standard of reference. He was also able to spend some time on Three Isles, north-east of Cooktown, and produce a similar map of that place. In 1936 there was no intention of spending a long time at any one island, but we visited and mapped as many as possible in order to obtain as much information as could be gathered of their development and structure. Experience soon showed that compass traverses were the only practicable means of mapping in the time available. It is fully realized that compass sketching cannot compare with Spender's maps in accuracy, but that is immaterial, because they are sufficiently exact to show the main physiographical features of the islands. In all twenty-seven islands were visited, of which fifteen were traversed and a sketch made. The work has shown that by no means all the features were noted in 1928, and it has also demonstrated that Low Isles is not to be regarded as the most typical example.

All these islands show similar ground plans. There are differences in detail, but not in principle. They are in the steamer channel and are all built on isolated reefs, each of which carries a sand cay to leeward and a mangrove swamp and shingle island or ridges to windward.[1] Sometimes these two units are well defined and separated; sometimes they have coalesced, and no bare reef-flat is left between them. Outside the shingle island the usual sequence of features is a platform or promenade of coral conglomerate, a moat, an outer rampart, and an algal terrace zone. These may be modified: there may be some dunes and occasionally inner as well as outer shingle ridges or ramparts. These variations will be noted in the individual islands.

These islands form a definite type in Queensland waters. They are not unlike certain islands in the East Indies as described by Umbgrove,[2] but there are important differences. They also occur in a limited part only of the Queensland coral zone. The farthest south is Low Isles; they appear to extend northwards as far as Torres Straits. Circumstances did not allow us to go farther north than Cape Direction, but between this point and Low Isles they are typically developed. As they are in the steamer channel they are clearly

[1] In many of the northern islands, *e.g.* Sherrard, Night, and Chapman Islands, the two islets are east and west of one another, and *not* to south-east and north-west of the reef flat.

[2] "De Koraalriffen in de Bai van Batavia, Dienst van der Mijnbouw in Nederlandsch-Indië," *Wetens. Med.*, No. 7, 1928, and Ph. H. Kuenen, "Geology of Coral Reefs," Snellius Expedition, vol. 5, Pt. 2, 1933.

differentiated from the inner reefs. Night Island is rather closer to the mainland than is any other. The area in which low wooded islands occur is therefore that where the outer reefs are fairly near the mainland and also where the outer reefs form a more or less true barrier reef. It is also the region of persistent south-easterly trade winds and the shorter season of summer calms and cyclones. They should not be confused with the Bunker and Capricorn Islands. True, both are low and wooded, but "low wooded island" is a term used on the Admiralty Charts for these islands alone. The main expedition in 1928 created the term "island reefs" for them. This is useful, but appears to have no advantage over the older term. It does not serve to differentiate them from the Bunker and Capricorn Islands, which are equally well described by the name. "Mangrove-shingle islands" is also unsuitable, as it neglects the sand cay part of the unit. There seems nothing to be lost by retaining the Admiralty term "low wooded islands," and it will be used in this paper.

Before attempting to draw any conclusions concerning their structure and evolution, details must be given of individual islands. Some will be described at length; others which are similar in pattern will be treated briefly.

(*b*) *Dhu* (=*D*) *Reef*

This reef with its small island affords an excellent example of an early stage of development of a low wooded island. The shingle ridges of the island are crescent-shaped and situated at the eastern end of the reef. At springs only the highest shingle banks would remain above water. On the flat to windward of the shingle banks, basset edges are well seen, and there is also some coral conglomerate on the south-western side of the island. *Avicennia* and *Sesuvium* are abundant on the basset edges, and *Rhizophora* is gradually extending inside the shingle banks and just beginning to form a swamp. *Avicennia* is also found on the inner side of the ridges, but at a slightly higher level than the *Rhizophora*.

Enclosed within the crescent of the ridges is the flat, transformed into a shallow lagoon at high water. To leeward there is a sand-bank awash after mid-tide. There is nothing on the whole island which can be definitely interpreted as raised. The lower platform is absent, its place being taken by the basset edges. The reef is a small one, but all the essential structures are present, in a rather elementary form, which make up the typical low wooded island. It is the best case we saw of the precursor of the stage to which Low Isles has attained. As there is a lighthouse on it which is regularly visited, it would be interesting, if possible, to have photographs taken at intervals in definite directions to establish its rate of development.

(*c*) *Ingram and Beanley Island and Pipon Island*

The first is one of two examples, as far as the writer knows, of a low wooded island having two names.[1] Ingram Island is the sand cay and Beanley Island the mangrove islet.

The cay is well developed and high, parts of it being about 20 feet above high-water mark. This results mainly from blown sand, so that in a sense the island

[1] The other is Farmer and Fisher Islets on the Piper Islands.

is a dune formed on a sand-bank. It is nearly surrounded by beach-rock, some of which has been formed at present level. But to north-east and south-west (approximately) of the cay are large masses of rock at a considerably higher level. Parts of this high rock have been torn off from the north-eastern end and thrown well into the sand of the island by a hurricane. The reef flat, especially extensive areas near the cay, was sanded over almost completely, and a new sand-bank to the north-west has formed. Much of this sand on the reef is blown by north-westerly winds; its effect is to give a very lifeless and dull appearance to the reef. Toward Beanley Island there is rather less sand and more *Thalassia*, but much of the reef, nearly 2 miles wide between the two islets, is very dull. Beanley Islet is a curious structure. The lower platform is admirably seen, and is occasionally intersected by gaps, which seem to be due to erosion and are narrow and quite unlike the wide spaces between the several parts of the platform on Night Island. The upper surface is very promenade-like, the outer edge very jagged. Moat and ramparts are usually absent and never pronounced. It is hardly too much to say that, as ordinarily understood, both these features are absent. In this and the following way it resembled Night Island. There was very little shingle or sand, in ridge form, on and inside the platform, which was the one striking feature. In places it was grass-covered, and *Sesuvium*, *Avicennia*, and *Suriana* were all present. In the gaps in the platform the algal terraces were rather striking. They helped to concentrate the ebbing tide in small channels and so lead to the formation of scour holes. The mangrove belt was narrow, and there was no real swamp. In pattern the two islets somewhat resemble Pipon Island, but in certain features they are more nearly akin to Night Island.

Pipon Island, immediately off Cape Melville, resembles Ingram and Beanley Island and in some ways Low Isles. The reef is a large one, and there is an extensive flat, largely covered with *Thalassia*, between the several components of the whole island-complex. The cay is nearly a mile from the mangroves and is a little unusual. It is a high ridge of sand, but allowance must be made for artificial changes. The lightkeepers' houses used to be here (the light is now automatic) and some of their foundations still exist and help to accumulate sand. The cay is surrounded by an admirable platform of beach-rock whose upper surface is very level. It has obviously not all been formed under existing circumstances, as the dip and strike are by no means always conformable to the present beach.

The main mangrove islet conforms to the usual pattern. The outer slope with algal terraces passes into a rather patchy outer rampart, which gives place to a still more patchy moat. Then follow some traces of the lower platform, and finally the inner shingle ridges, which are well developed and form small but true islands. Sometimes the platform reappears inside these ridges. A point of some interest here is that, although this island is in a peculiarly windy place, the wave fetch, on account of numerous reefs, is small. Hence various slight modifications in ramparts and other features are to be expected. The mangroves behind the shingle ridges are gradually spreading leewards, and so give a park-like aspect resembling Low Isles.[1]

[1] A shallow bore, 5 feet, was put down near the north-western corner of the mangroves. It passed through compacted shingle and sand all the way.

On the south and south-eastern side of the reef algal terraces and a low, but distinct, outer shingle rampart are seen. The boulder zone is best developed on the northern and north-western sides, though there are some scattered boulders on the reef-flat.

Waves have also built other shingle ridges on the southern parts of the reef rim, and the present light stands on what is nearly the third island. It is doubtful if any part of it would stand above a big tide, but shingle ridges, *Avicennia*, *Sesuvium*, and *Rhizophora* are all in their "right" places, and it is clearly a small shingle island in process of formation. Other islands are forming on the weather side of the reef between the big mangrove island and the lighthouse island. They are yet only low shingle ridges with some *Avicennia*.

(*d*) *Night Island*

This is a large island. The cay, wholly made up of sand, is long and narrow and runs north and south along the western side of the reef. It is clearly differentiated from the mangroves, although they extend inwards so as to touch it, and it is flat in cross-section. The vegetation is thick, consisting of trees, creeping plants, and grasses. Some coconuts have been planted quite recently. On the northern and north-western sides, beach-rock is well developed, but separated from the present beach by a narrow belt of mangroves. A poorer example is found on the western side. To the south the cay tapers and forms a long, low sand-spit, built up in the last few years. This spit is now invading the mangroves behind it, and numerous small trees are still growing up through it. Some few years ago the island was devastated by a cyclone, and the effects on the mangroves are clear. Dead tree trunks are prostrate on the western side of the spit and large areas of the mangrove belt proper are now dismal swamps of black mud and dead trees, some still standing, most of them prone. Several large clumps of living trees survive, and the whole place reminds one of pictures of a partially shelled forest on the Western Front during the war. The open parts are now gradually being re-colonized by *Rhizophora*, so that in parts the park-like aspect is more marked than in other islands. The entire mangrove area is extensive and encloses the sand cay on all but its western side.

A marked feature of this island is the absence of shingle ridges on the weather side. The lower platform is well developed, but is far from being continuous. Reference to the map will show better than words how this platform appears on the ground. *Avicennia* is usually present, but is not abundant. Shingle is scarce on the platform; there is a little on the two most southerly fragments. *Suriana maritima* is always found on the platforms, all of which appear to be quite normal, though their upper surfaces are sometimes much worn and basset edges are consequently prominent.

Algal terraces are prominent between and outside the platform-fragments. Sometimes they cause minor waterfalls, 6 inches or so high, when the water is draining off the flat. As rampart shingle is practically absent, there is no real moat along this island except at the north-eastern end, where a large outer shingle ridge occurs. A moat is found inside this and also along part of the northern side of the island. To north-west the mangroves have spread outwards and have killed much of the reef. This area of dead and very muddy

reef may represent evidence of the upward movement which, it is here claimed, gave rise to the lower platform. It resembles the reefs at Stone Island and Holbourne Island in several ways. Much of the mangrove area is sand-covered, and there is a marked growth of *Thalassia*. In short, the island conforms to the general pattern, but the absence of shingle ridges, the discontinuities in the platform, and the abundance of *Rhizophora* are facts worth noting.

(e) Houghton Island and Coquet Island

The former is a large and interesting island. It is elongated roughly east and west, and for this reason looks at first sight rather unlike the ordinary low wooded type. It may be regarded as one of a group of three, the others being Howick and Coquet. Howick was mentioned in 1929; it differs from the other two in that it is partly a continental island. Two or three granite masses have been joined by a reef which extends 2 or 3 miles westwards from them. The intervening space between the solid rocks and the sand cay, on the eastern end, is a dense mangrove swamp. Houghton and Coquet are similar, except that no solid rock shows. The sand cay on Houghton Island is large and highly developed; it is a true cay with a little scattered shingle near the mangroves (see map). It is largely bordered by beach-rock, some of which (see Section 7) stands high. The cay itself is considerably higher than usual, and the impression forced upon one when on it is that this, too, is due to an upward movement. It is not merely that there are a few high ridges: the whole body of the cay stands high. The top of the high platform surrounding part of it is level and smooth, and a low platform is now being cut into this ancient beach-rock 6–7 feet below its raised surface.

Stretching windwards from the cay the conglomerate platform is sharply developed and is continuous over long distances. It is always lower than the surrounding parts of the cay. In places it lies behind shingle ridges and small lagoons; at other places it is very jagged and eroded. Taken throughout it is remarkably level. The eastern end of the complex shows a typical shingle island, built of ridges and tongues of ordinary shingle, which penetrate into the mangroves. All the usual features are present; *Avicennia*, *Sesuvium*, and *Suriana* occur in the conventional places. Moat and rampart are also present, though not always clearly cut. Outside them algal terraces are seen. On the northern side of the island the mangroves give place directly to the reef-flat without any ramparts or moat. Boulders rest on the north-western and northern corners of the reef.

Coquet Island is similar. The sand cay is unusually large and has some shingle ridges banked against its southern side. A fair amount of beach-rock is also found on the cay. Unlike Houghton cay, this one has grown in such a way as to enclose lows within itself in which mangroves still grow. The cay is a high one. A shingle islet forms the eastern end of the complex. It is situated well within the reef edge, there being a low with some mangroves in front of it. The shingle islet is fringed by a platform which is higher than the outer platform running between the sand and shingle cays, but it would be misleading to suggest with any degree of finality that it represents a different level. Moat and rampart occur, the former often being separated into lagoons

by shingle tongues. A generalized section at the eastern end of the island is given on the map.

The central mass of the island consists of a mangrove swamp, which to the north gives way directly to the reef and to the south is fringed by the lower platform and ramparts.

The whole structure closely resembles Houghton Island, from which it is distant only 2 miles. These two with Howick Island form a group and should be considered together. They are all elongated reefs, and it would be interesting to put a bore down on Coquet or Houghton Island to test the depth of the coralline material which is, as it were, pierced upwards by the outcrops of solid rock on Howick Island to the north.

(*f*) *Bewick, Low Wooded, King, and Enn* (=*N*) *Islands*

The component parts of one group of low wooded islands are beautifully shown in Bewick Island. The sand cay, bordered to west and north with beach-rock and clothed with grasses, creeping plants, and small timber, is clear and absolutely distinct from the mangroves which surround it on all but its western side. The great mass of the island is a mangrove swamp with occasional open glades and lagoons. To north-east and south-west the mangroves give place directly to the reef-flat. Along the whole of the windward side the swamp is hemmed in by a discontinuous series of shingle ridges, most of which are high and big enough to carry a land flora and to form true islands at all stages of the tide. The lower platform is well developed; usually it follows on the outer side of the shingle ridges, but sometimes new ridges have grown up in front of it and small lagoons thus come to be enclosed. The platform is discontinuous and is usually most broken where wide channels debouch from the mangrove area. The whole complex occupies most of the reef, leaving but a narrow flat with occasional ramparts and honeycomb rock with *Avicennia* and algal terraces outside the island.

It is a good example of a more or less circular reef which has now reached a fairly advanced stage of island development. It differs in many ways from a structure such as Low Isles.

Comparable with this island is Low Wooded Island, situated between Capes Bedford and Flattery. It is more oval in form, but consists of a thick mangrove belt surrounded by the lower platform and shingle ridges. The latter are by no means as well developed as on Bewick Island, but are of the same general nature. They form small but distinct islands. Moat and ramparts occur in the usual places. The main point of difference is the poor development of the sand cay on Low Wooded Island. There is a sandy cay-like area to the north-west of the mangroves, but it is almost entirely surrounded by shingle ridges, which are the continuations of those around the mangroves. The north-western end of the island consists of a modern sand and shingle spit. Allowing however for these rather minor differences, the two islands are in much the same stage of development, but Bewick Island is the more interesting.

King Island, sometimes spoken of as Low Woody Island, lies a few miles north-east of the Flinders Group. The cay is irregular in shape, having two long horns. Apart from this it is quite normal. The best stretch of beach-

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Hannah Island

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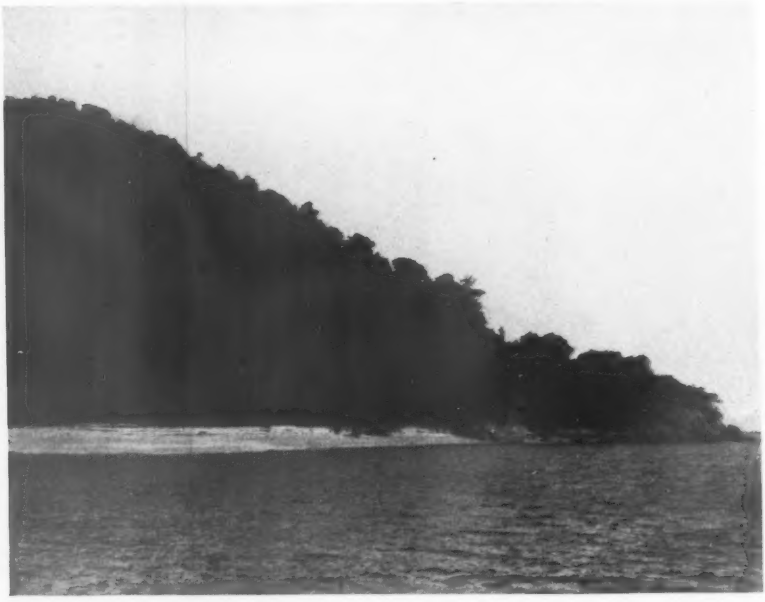
Beanley Island. Gap in conglomerate platform



High Island. North-west sand-spit

Shingle Island. Moat rampart

Hay Island. Low shingle rampart, moat, and lower platform

rock is to the north-west of the cay; *Avicennia* and *Sesuvium* grow on the rock and *Suriana* fringes it in the rear. The separation of cay and mangroves is distinct, and the boulder zone lies to north and north-west of the cay. Platform, moat, and rampart are all well developed on the shingle island. There are, in fact, several shingle islets formed, as in other cases, of ordinary ridges of shingle, here rather coarse. To the south-east the ridges become higher and broader, and sometimes enclose lows between them. *Rhizophora* usually grows in the lows, some of which are dry. On the south-east of the complex the shingle ridges make an island about 100 yards wide, and appear to be raised. The platform (lower) is often rather old-looking and worn, but *Suriana* is growing on it in places. The general aspect of the whole island was very reminiscent of Low Wooded Island, except that here the sand cay is distinct. In places there is a good development of an inner platform on which high shingle ridges have accumulated. It is realized that cyclones can throw material to the height of these ridges, and also that by successive progradation the shingle islet can extend windwards, yet it is difficult not to assume a vertical movement over this island. The inner platform on which these ridges stand is about 1½–2 feet higher than the outer, normal, platform, but it is not suggested that it represents a separate movement. The two platforms, virtually at the same level, the high shingle ridges, and the general conformation of the weather side of the island strongly suggest that the normal low platform of this and most other islands is raised.

The section shows roughly the principal features of the weather side of the island. The heights and distances are only estimated, but are relatively correct. All the interior of the island is a mangrove swamp, with some open glades. On the north-west the mangroves spread, park-like, on to the reef.

Enn (=N) Island may perhaps be regarded as a standard of reference. It stands on a circular reef and in a fairly isolated position. The island complex takes up most of the area of the reef, a belt varying between 150–300 yards wide only remaining outside the island. The cay is on the western and north-western sides. It is rather elongated in form, and its inner edge is not very distinct. It carries a certain amount of beach-rock and stands relatively high, suggesting that it conforms with the high conglomerate platform mentioned below. The central part of the reef-flat is occupied by mangroves. On their outer side (see map) they are for a long distance on the north-east fringed by a wide and unbroken belt of shingle ridges which form a true island of some size. They drop down to the reef-flat through dry moats and shingle ridges, or farther south give place to the higher platform which stands at the back of a lagoon held in by long shingle ridges (*i.e.* the outer rampart). Outside the inner ridges are basset edges with *Sesuvium*, which in turn give place to the reef-flat with its algal terraces. At the southern end of this lagoon the upper and lower platforms come into contact (see Section 7). To the south the higher platform is better developed than on many islands visited, and stands 7–9 feet above the flat immediately in front of it. It is in this part that the platform is undercut to a remarkable degree. At the south-western end of the island a shingly mass, surrounded by the lower platform, has been attached to the main island by a ridge of shingle. The bay between this and the main island shows

an old reef surface, now sanded over and dead, which may certainly be regarded as a raised reef.[1] The high platform, this dead reef, the unusual height of the sand cay and shingle ridges, make it quite certain that considerable upward movement has affected this island. As the lower platform is also so well shown, the writer regards this island as one indicating a double upward movement relative to sea-level, and so comparable with Houghton Island and Coquet Island.

(*g*) *The Claremont Islands, omitting Night Island*

Between Cape Direction and Claremont Point there are several small islands, in addition to Night Island, which belong to the low wooded group.[2] Chapman Island is the most northerly we were able to visit. The island is entirely made up of shingle ridges. There is a thin soil and some guano, and the interior part of the island may have been excavated by man. There are some rather poor remnants of the lower platform on the weather side, but basset edges usually take the place of a well-defined platform. There are mangroves, but they are scantily spread. Some are in hollows within the shingle ridges. The cay is represented by a sand-bank awash at high water. It corresponds in all other ways with the cay of similar islands. The usual common plants are all found on the shingle islet. Though there is nothing very peculiar about this island, it is worth while stressing that the shingle cay is the major feature, even though it is a small one.

A few miles to the south is Sherrard Island. Here cay and shingle island are distinct, and lie nearly east and west of one another. The shingle islet is very small, but the outer rampart, moat, and lower platform are prominent. The shingle ridges on and inside the platform constitute the islet. *Rhizophora* is just beginning to colonize the flat; at the time of our visit there were only two well-grown trees. But all the features are in their normal positions. It is more than likely that cyclones have altered the appearance of this islet, as their results are clearly exemplified on the sand cay. Our pilot, Mr. Moynahan, who has known the island for many years, said that the cay is much smaller than it was twenty years ago. This is supported by field evidence, for there are several long lines of beach-rock to the side of the present cay. These once included a larger island. The present cay has no beach-rock around it. The reef-flat between the two islets is very sandy, and the northern side is boulder-strewn. Boulders, in fact, margin most of the reef, but are most conspicuous in this part. The sand cay is vegetated.

Binsted Island is small, and about 2 miles south of Night Island. The lower platform is the dominant feature; the shingle islet seems to be built on it and consists of ridges arranged in a roughly concentric pattern. To the north-west the islet is prolonged by a long shingle spit with a good example of a moat inside it. *Avicennia* is present, but only a few *Rhizophora* trees. The cay, as at Chapman Island, is represented by a bank awash at high water. The main

[1] Parts of dead reef surface can be seen to extend under the high platform where erosion has made large cave-like hollows. Ordinary outer ramparts occur; see map.

[2] The only reference to these islands, apart from Admiralty publications, I have come across is a paper by G. F. Mathew, *Proc. Linn. Soc. N.S.W.*, x, 1885–6, p. 251. Mathew landed on No. 5, *i.e.* Fife Island. He speaks of it as Espiègle Island, after the name of his ship. The paper gives a very general account of its natural history.

boulder zone is on the north-western part of the reef. The platform shows many signs of breaking down into basset edges.

Lowrie Island lies a little farther south. The outer rampart is here magnificently developed, and falls steeply for about 4 feet into an equally well-defined moat. The platform is behind this, but consists chiefly of much-eroded basset edges. The islet is made up of a mixture of sand and shingle, the latter being in ridge form on the outside of the islet. On the south-western side there is a good deal of beach-rock and conglomerate which shows the mixed nature of its constituents in much the same proportion as they appear on the islet. It would be difficult to contend that this particular rock indicates any uplift; it is certainly covered at high water. On the other hand, the mangroves have now spread in a thick belt outside of it. The vegetation is thick, consisting mainly of low bushes, creeping plants, and grasses. The rampart shingle runs back from this islet and practically joins it to the cay, which also consists of rather mixed coarse and fine material. This second and smaller islet is grass-covered and the nesting place of sea fowl. The two islets are about 200 yards apart. Even if rather exceptional in not being clearly differentiated in the material of which they are formed, the main features of both relate them quite clearly to the mangrove and cay islets of the other islands. Boulders again are most prominent on the northern and north-western sides of the reef. *Rhizophora* is beginning to grow along the eastern side of the smaller islet.

Hay Island is considerably larger than those so far described in this section. The sand cay is long and narrow, trending east and west, and lies to the north of the mangrove area, from which it is distinctly separated. Beach-rock is found on it and a coarse shingle and boulder zone occurs off its north-western corner. The beach-rock does not unquestionably indicate uplift. Some of the mangroves have already spread north of the cay, as if beginning to enclose it completely. The island has a derelict appearance, much of the mangrove belt having been blown down in a cyclone, and the dead trees rest on a sanded and dead reef. The rampart in the south-west is very steep, and the outer boulder zone is best seen on the western side. A platform, with the accompanying plants and rather worn down to basset edges, occurs to south and south-east, where there is also a moat and low outer rampart. The platform, as at Night Island, is discontinuous. It is colonized by *Avicennia*, and, as usual, *Suriana* grows on its inner side. It differs however from Night Island in that there is much more shingle on the platform. There are also traces of a platform, showing a strong inward dip of its basset edges, 2–3 feet higher than the lower one. So far, new mangrove growth has not been very successful in recolonizing the devastated area.

Wilkie Island is a still more depressing place. The cay is purely sand, formed in such a way as to enclose lows containing mangroves. To north-east and east a long shingle ridge runs from the cay inside the outer mangrove belt, including the now devastated area, and fans out to the south-east. The mangroves rise from a sandy surface of a dead reef. Frequent traces of the lower platform are found outside the bank; these are extremely rough. The moat and outer rampart are the best features of the island, and are often beautifully formed. Fine algal terraces occur in the occasional breaks in the outer rampart, and also on its outer side. To west and north-west the mangrove belt

gradually gives place to the reef-flat; there is no defined boundary. It may be noted that mangroves nearly surround the cay.

Hannah Island again shows all the usual features, but the cay is entirely surrounded by mangroves, though only a thin belt grows on its north-western side. From the top of the lighthouse a good view can be obtained of the island, which has been partially wrecked by a cyclone. Further detail is unnecessary, as it is very like Wilkie Island, but mention may be made of the very fine ramparts and moat.

Burkitt Island is somewhat similar, except that the cay is here formed of separate ridges of sand and is not of the common compact form. Deep hollows lie between the ridges enclosing water, mangroves, and crocodiles! The connection between platform and basset edges, seen so well on this island, is described in Section 8. The mangrove belt contains open areas and is often more park-like than on the other islands. The shingle of the weather side ends rather abruptly in a high knot rather like the corresponding knot on Low Isles. The outer rampart, moat, platform with basset edges, and, in places, a high inner rampart follow eastwards from the knot. To the south-west these features die out, and the mangrove belt also thins, giving an "open-country" aspect to this part of the reef.

(*h*) *Newton and Watson Islands*

Two other small islands may be mentioned briefly. Newton Island shows all the expected features. The sand cay is rather large for the size of the reef and carries a good deal of beach-rock, though by no means all of it in conformity with its present shape. Without question changes of form have taken place in the recent past. The shingle islet was perfectly normal, and calls for no detailed description.

Watson Island [1] had to be inspected from the boat. It is situated on a small reef about 2 miles from Newton Island. The shingle islet showed no exceptional appearance. Ramparts are probably present on the south-east, but the island was not completely circumnavigated. The cay was interesting in that it carried no vegetation which could be detected with glasses. Mr. Moynahan did not remember ever having seen any on it. There was however some beach-rock. It is therefore possible that this is an exceptional case; but it must be remembered that the cay may alternate between a bank and a true cay and never remain unaffected long enough for any vegetation but creepers and grasses, which can soon disappear in a storm, to take root.

(*i*) *Turtle Group*

The Turtle Group, consisting of six islands and a few small reefs, deserves a separate section. The islands are not named separately and are here referred to by numbers, in the order in which they were visited.

Turtle I. This is a rather complex island and somewhat unlike those already described. There is a sandy area in the north-west which represents the cay, but it was not possible to trace any clear line of demarcation between this and

[1] Named after Mrs. Watson who, after escaping from natives on Lizard Island, drifted with her baby and a Chinese servant in an iron tank to this island, where they died of thirst. There is a monument to Mrs. Watson in Cooktown. This island is referred to as Warson Island in the 1917 edition of the *Australia Pilot*, vol. 4.

the rest of the island. The remainder, and by far the greater part, consists of shingle ridges having a rough west-north-west to east-south-east trend. The interior of the island is grassy; trees enclose it on all sides. To windward the lower platform is prominent and stands about 3 feet above the present reef-flat. Mangroves surround the southern and eastern parts of the island, and there are also patches elsewhere. However the mangrove belt is by no means as well developed as on most islands. *Avicennia* and *Sesuvium* grow on the lower platform and *Suriana* on its inner edge. Ramparts and moat are present. The cay-like area has an old aspect, and the shingle ridges run up to it, though sometimes, as on the west, separated by a channel.

The shingle ridges inside the island stand high and are consistent with the view that they were built when the platform was at its original level. Modern white shingle ridges are found on the platform, due presumably to hurricanes. But it is doubtful if their occurrence means that the platform is a feature constructed at present level. Our visit coincided with a south-easterly gale, but the plants growing on the platform were undisturbed. Fragments of old conglomerate platforms are also found well inland, but usually behind mangroves. The cay also stands high and is consistent with uplift, although it is fully realized sand can easily be blown to a height and give a misleading appearance.

Turtle II mainly differs from Turtle I in that no trace of sand was found on it. The lower platform is rather striking, and is level and unbroken along almost the entire length of the weather side of the island. It is backed by a hurricane beach, which, incidentally, is much interwoven with and overgrown by trees and plants. The platform is mainly bare, but *Avicennia* and *Sesuvium* are seen on it. In the south-east it breaks down into basset edges and *Avicennia* becomes much more abundant. The north-eastern side of the island is enclosed by a modern shingle ridge. The whole island is surrounded by a broad reef-flat; moats and ramparts were inconspicuous. The interior seems to be made up solely of shingle ridges rising, by estimation, 15–18 feet or so above the reef-flat. They strongly suggested, as on Turtle I, that they were raised and formed before the platform came into its present position. Scenically, the interior resembled the former island. At the extreme north-western end of the reef on which this shingle island stands and about a quarter of a mile from it is a sand-bank. This corresponds precisely with the position a cay should take, and completes the entity of the reef.

Turtle III is a much smaller island, and is virtually a sand cay with subsidiary shingle, mainly in the form of a short and modern ridge to south and south-east. There are however remains of the lower platform with *Avicennia* and *Sesuvium*, and so it differs from a true cay. *Rhizophora* was absent. New sand ridges have been added to the northern and north-western sides, and have covered part of the platform. The interior is sandy and level, with scattered shrubs and grasses. There is a moat and a fairly wide reef-flat and also some beach-rock to the east and north-east.

Turtle IV showed no unexpected features. The ramparts are well developed, and the cay consisted rather of fine shingle than true sand. Some beach-rock existed along parts of it. The lower platform was wide and extensive, considering the size of the island, and some ridges of coarse shingle enclosed the

cay-like area. No landing was made on Turtle V and Turtle VI, but they presented no unusual features as seen from the ship sailing close in to the shore.

Perhaps the most interesting feature of the whole group was examined on a small enclosed reef in the midst of them. To windward there was a shingle-bank, an immature rampart, and to leeward a sand-bank, both covered about mid-tide. The two features were, in miniature and in embryo, a complete low wooded island. They seem exactly comparable to the stage, quoted by Spender, reached on Bee (=B) reef.[1] This reef, a little south of Cooktown, was also visited. It is long and narrow. We made a "landing," and found that a ridge of shingle, awash at mid-tide, extended along nearly its entire length. It did not however show any definite suggestion of being in an early stage of development of a low wooded island, whereas the reef in the Turtle Group afforded a perfect example.

(*j*) *Kew* (=*Q*) *Islands*

Brief mention may be made in this place of the Kew Islands, two in number, to the west of the Turtle Group. The south-westerly island was examined. The main islet was made of shingle ridges, with a good inner rampart to north and north-east. At its apex this rampart enclosed a deep low into which mangroves are spreading. Farther round to the south-east traces of the lower platform were found, though usually very broken on the outside. Much of the reef is dead. The mangroves enclose a lagoon, and the lower platform is best seen within them. The island is continued to the west by a prominent and high shingle ridge. After a gap this line is continued by a remarkable mass of isolated beach-rock and conglomerate, standing about 4 feet above the reef-flat. It presumably formed along an earlier cay, none of which is left. Beyond this again is a sand-bank, with some fine shingle, awash at high water. There is no beach-rock on this bank. Seen from the boat the second island appeared to be quite typical, but the small cay was clearly a bank of shingle, not sand, also awash at high water.

(*k*) *Hope Islands*

In 1929 these two islands were particularly mentioned because it was then thought that, while exceptional in one way, they conformed to the general pattern by having the shingle and mangrove islet on the one reef and the sand cay on the other reef. The two reefs are separated by a channel of deep water about 4 cables wide; and unless each is visited and explored, it is easy to obtain such an impression. It is however only a half-truth. The mangrove islet is on the weather side of the western reef, and conforms to the usual structure (see *Geogr. J.* 76 (1930) *op. cit.*). On the lee end of the *same* reef the charts mark a sand-bank awash at high water. At the time of our visit (July 1936) this sand-bank had deteriorated to a spread of sand covered when the least possible amount of water was on the reef. But there was no doubt that the sand was there: it was merely spread out flat. It formed a potential cay. On the eastern reef the sand cay is well developed. On the windward end of the same reef are some low shingle banks, ramparts in embryo, and some basset edges forming a rough horse-shoe pattern with the horns running towards the sand cay. Two

[1] Hedley and Taylor (*Australasian Assoc. Adv. Sci.*, Section C, Adelaide Meeting, 1907) refer to this reef. Its "surface features" have changed greatly since they visited it. Spender's views (*Geogr. J.* 76 (1930) *op. cit.*) are based on their description.

Avicennia trees were growing on them. Hence it is but partly true to say that the cay is on one reef and the mangrove islet on the other. Each reef is in fact an entity. Their shape and close proximity seem to have favoured the present development, but each reef is, if one may so say, trying to conform to pattern.

(*l*) *Two Isles*

There is no need to discuss the structure of Low Isles and Three Isles, as this was done in detail by the previous expedition, but a note is necessary on Two Isles, which lies a few miles north of Three Isles. The sand cay is probably the finest we saw; it is high and carries a forest vegetation, there being many well-grown trees. The weather side is less densely covered, *Pandanus* being the commonest tree. There is much beach-rock around it, but probably all, with the possible exception of some near the north-eastern corner, was formed at present level.

The reef-flat practically dries out at low spring tides. The mangrove belt is rather disappointing. The usual features are present, but not well developed. To the south-west of the main mangrove islet some new ones are developing. Basset edges, approximately level with rampart ridges, are seen. We felt much less convinced here than anywhere else that the platform is a raised feature. The new islets in process of development seemed to show that ramparts were passing into basset edges without any change of level. There was no feature seen on the mangrove islet which could indubitably be taken as indicating that it had experienced a recent vertical movement. In this it resembled Low Isles, but contrasted strikingly with Three Isles, with its two platforms.

(*m*) *Howick, Clack, and Cockburn Reefs*

In concluding this section reference may be made to Howick and similar islands (Section 9 (*e*)). Clack, Cockburn, and Howick Reefs have each joined together various rocky islands, and extended considerably beyond them so that cays have occasionally formed to leeward of the reefs, and mangrove swamps in the shelter of the high islands. There is nothing exceptional in these islands, but they serve as a warning against over-classification. It is convenient to speak of high islands, cays, and low wooded islands, but it is wrong to insist too strongly on their being absolutely unrelated structures. Given the proper conditions a reef, which may possibly begin as a fringing reef, will form round a high island, will grow more quickly in one direction, and attain a sufficient size so that wave erosion can produce material which may later be built up into a cay. Ramparts of shingle may form to windward of the high island, and so the structure is complete. Howick Island illustrates these points extremely well. Although these islands are best developed in the northern part of the reefs, it is pertinent to point out that Bushy Island (Section 4) is on the same reef as an isolated rock, named Redbill Isle. There are however no mangroves on this reef.

10. The Formation of Low Wooded Islands

Many of these islands have been described in some detail. The general problem of their origin must now be discussed.

It will be apparent that although there are differences in detail between them, there is nevertheless a striking similarity of structure. In 1929 it was

suggested that the cay was probably formed first and the shingle islet later. Whilst nothing directly contradictory to this was seen in 1936, it is relevant to call attention to the unnamed reef in a very early stage of development in the Turtle Group. Here shingle and sand are collecting contemporaneously. In early stages this is probable. The shingle ridges have not grown sufficiently to hinder wave-action to any marked degree on the rest of the reef, but once the ridges have reached a reasonable stage of development it seems probable that they would arrest the formation of the cay. Hence, the cay may grow more quickly than the shingle islet. Sufficient examples have been quoted to show that it is likely to have a chequered career: a storm or a cyclone from a north-westerly quarter may cut it away entirely. This is not likely to happen once it has a fair spread of beach-rock and vegetation. Both are stabilizing influences, and the former the more effective. The balance of evidence however is in favour of the vegetation preceding the beach-rock, but no definite reason can be given for this. The shingle islet is on the exposed side of the reef and will also have a mixed career. The shingle is the direct product of the erosion, by waves, of the reef, and is thrown up as a ridge or rampart. There is nothing to suggest that it starts to accumulate around one or more large boulders, and there is no particular reason why it should do so. As on any shore, a ridge will be built if the supply of shingle is sufficient. At first it will be small, but sooner or later growth leads to some degree of stability. The ridges will lengthen in the usual way, or adjacent ridges will join together. The ridges will obviously be concentrated mainly at the south-east, but will lengthen down wind in course of time. The configuration of the reef will naturally have a good deal of influence. Sometimes conditions favour long ridges of shingle along the eastern side of reefs and the incurving or piling up of shingle at the north-eastern end of the reefs. There is nothing exceptional in this. Tongues of shingle, even 30 or more yards long, flat in cross-section, are often seen to run inwards at right-angles to the outer, or even inner, ramparts. They are always narrow. Spender discussed them at some length in 1930, and I agree generally with him. They are almost certainly formed in stormy times by waves breaching a rampart in a weak point and trailing out the shingle as an inward-pointing tongue. They are sometimes found isolated, away from a regular rampart. It is difficult to explain this form; we may agree that a local pile of shingle has been elongated, but the reason for the original pile cannot be explained except on such vague grounds as a greater local supply of shingle in a particular place. Spender's maps of Low Isles and Three Isles show their form excellently.

The moat is largely the direct product of these outer ridges or ramparts. That it is often a zone of relatively luxuriant coral growth may follow from the impounding of water, and partly from a certain scour which will take place in the moat when draining out at ebb. Sand and other fine material will be carried out in this way. The algal zone in front of the rampart or in its breaks or in the gaps of the platform is due to organisms which are favoured by such an environment, *i.e.* one in which water is flowing out during most of the ebb and also one that is under water during the greater part of any tidal cycle. As discussed in detail elsewhere, the platform and basset edges[1] are here regarded

[1] *I.e.* only those at a level corresponding with definite platforms; those at lower levels afford less certain evidence of uplift.

Hay Island: devastated area from north-west. Boulder zone and mangroves

King Island. Meeting of sand cay and mangroves

King Island. Rampart shingle

One Tree Island. Shingle

as a former rampart, now slightly raised, and suffering erosion. Spender's cyclical suggestion does not seem in accordance with the many features in the reef area which suggest uplift and are consistent with the platform. Inasmuch as ramparts are not likely to be all at the same height, there is no need to expect platforms to be so, and hence, if some islets show only basset edges they should not for this reason alone be regarded as negativing a recent movement. The fact that new shingle is sometimes found on the platform is not inconsistent with the idea of its having been raised. Severe storms and cyclones could easily throw this shingle up.

The same explanation applies *a fortiori* to any higher platform that may occur. Further, the modern shingle ridges will not always form single lines. Exposure to storms will easily produce conditions allowing the growth of ridges one in front of the other, and so eventually lead to the present occurrence of small mangrove areas within the ridges. The occasional dunes on the shingle islets are due to wind-blown sand, but the supply must be very limited because there is no spread of sand on the reef-flats in front of the shingle. Sand which is spread over the reef in the rear of the mangroves is, in the first place, due to erosion of the reef, but its present occurrence in such places is more reasonably explained as material blown from the cay or bank during cyclones. Mr. Moynahan's personal observations bear this out in certain cases.

The mangrove belt will vary in size partly according to the area of the reef, but presumably still more so according to purely fortuitous circumstances, including the supply of seeds, the tidal conditions, and other factors which cannot be calculated. Given time it is clear that the mangroves can not only cover the reef behind the shingle ridges, but also enclose the cay as well. *Avicennia* is confined to the rather higher parts of the tidal island complex, and its usual position outside the shingle ridges is due to this fact.

The cay, as stated, starts as an ordinary sand-bank, and although its original size may have some relation to the size of the reef on which it stands, it is obvious that there is no general rule. Big cays often occur on small reefs and *vice versa*. Their origin is precisely the same as that of the cays described in Section 4. Incidence of storms, general weather conditions, rapidity with which seeds are brought to them and germinate, slight changes in sea-level, and the rate at which beach-rock forms around them are the factors which control their future growth. These factors are obviously incalculable.

It is uncertain why low wooded islands should be limited to that part of the coast between Port Douglas and Torres Straits. Tentatively it may be suggested that it depends on the following factors:

1. The south-east trade wind is very persistent along this part of the coast.

2. The islands are always within that part of the reef zone which may be called a true barrier reef.

3. Hence the waves and seas produced are short and steep when the trade is blowing at or above its normal strength. These waves break on the reefs and produce rampart shingle, and by eroding the reef produce the sand of which the cay is built. The shingle island and cay are both in equilibrium with the forces to which they owe their origin.

4. The somewhat less developed condition of Low Isles as compared with

its more northerly counterparts may be partly due to the fact that it lies nearer the southern margin of the zone of maximum trade wind activity.

5. The outer and inner reefs exclude the full ocean swell, which, on the outer reefs, seems to prevent the formation of shingle ridges.

6. It may possibly be that there is more material of a less compacted nature to the windward of the steamer channel reefs which is subjected to wave erosion than is the case on the outer barrier series.

7. The fetch of the waves, whilst never very extensive, is rather greater than that which influences waves attacking an inner reef. It is this fact which appears to be the main reason for cay growth on the inner reefs and low wooded islands on the isolated reefs in the steamer channel (*i.e.* neglecting minor individual differences in the level of reef surfaces at the present time).

8. As a negative point, it should be noted that there are no features corresponding precisely to ramparts in the Bunker and Capricorn Islands. Both these groups are subjected to powerful wave-action from open water; and, incidentally they lie in an area of much more variable winds than do the low wooded islands.

9. The size of the reef seems to have but little to do with the degree of development of the low wooded islands, if the stages to which the shingle islet and cay are, as I think they should be, taken as the main criteria. Exposure to persistent winds seems to be the real factor. The development of the mangrove swamp may give a misleading impression of maturity.

10. Much allowance for the effect of severe cyclones must be given in considering the development of certain islands. Not only may they produce such obvious changes as blowing down much of the mangrove area, they may also be responsible for distributing former ramparts as a thin spread of shingle over the reefs. In this connection it would be interesting to know whether ramparts used to exist on Night Island where they are now absent or but very poorly developed.

11. The platform is claimed as a feature indicating a recent slight fall of sea-level. It is also regarded as having originated as a rampart before the change of level took place. If this assumption is correct, it means that the present outer ramparts have been formed since the shift in sea-level, and that the shingle and sand cays were possibly formed earlier, at least in part.

It may be suggested, very tentatively, that the reason why, *e.g.*, Dhu Reef shows no true platform is that as a result of the presumed recent change in sea-level it is only now at such a level with respect to the water surface that an island-complex can form on it. A similar explanation may apply to some other steamer channel reefs which have not yet become low wooded islands.

11. Low Isles

The detailed reports of the 1928 expedition and Spender's map gave a full account of this low wooded island. The modifications which took place as a result of the 1934 cyclone have been described by Moorhouse, and were confirmed on our own visit. It appears however that by 1936 the cay had practically regained its former shape. Moorhouse did a valuable service in

remapping an island which, if it escaped the full force of the cyclone, nevertheless experienced a very severe blow.[1]

It is relevant here to relate Low Isles to the type low wooded isles as a whole. Somewhat naturally it is apt to be regarded with Three Isles, as the "standard" island. This is a little unfortunate. In the first place it must be emphasized that there is scarcely any shingle islet at Low Isles. One or two minor ridges remain dry at high water, but their area is very small. It has been shown that the shingle islet is often the more important of the pair found on most reefs on which this type of island rests. At Low Isles the cay is the dominant structure. It seems that the reason may be found in the absence of a platform at Low Isles. Basset edges occur not very frequently, but there is hardly a true platform. In most other islands shingle ridges piled up either on or inside the platform make true islands.

The differences which exist between the mangrove belts on this and other islands are not of fundamental importance. The number and spread of these trees must be governed by a number of what may be termed chance factors. But the park-like aspect of the mangroves on the reef-flat between the thick mangrove swamp and the sand cay is perhaps more noticeable at Low Isles than in any other case seen by the writer. It has been shown that on many reefs the mangroves have spread over the flat and reached, even if not partially surrounded, the sand cay.

The Anchorage is, I think, a more pronounced feature at Low Isles than elsewhere.[2] Some reefs do show a small bay on their lee side, but of those we visited there was none which compared with that at Low Isles. In this respect Spender's map of Three Isles is more typical, and incidentally shows that the cay may form on either side, or even partly in the anchorage. Stephenson [3] suggests that Low Isles may consist of two reefs joined together. The shape of the present flat and its surface contours bear this out, but the point, unfortunately, cannot be proved. Should it be so however it would help to account for the more pronounced anchorage there than at any other comparable island.

A careful study of the detailed charts also suggests that anchorages are rare. It is true that the scale of the charts hardly permits the minor embayment, which corresponds to the anchorage at Three Isles, to be shown, but allowing for this, and also for the absence of a true anchorage on many islands visited in 1936, I feel that the feature should not be regarded as really characteristic of these reefs, though it should be noted that what is known of their growth and structure suggests that an incipient embayment or a lower level of the reef-flat is at least a potential feature on their leeward sides.

These appear to be the main ways in which Low Isles differs from similar islands, and some of the features noted suggest that it is in a comparatively young stage of development. It is difficult to resist the conclusion that it forms a stage later than that attained by Dhu (=D) Reef, and that it is

[1] Spender contributed a note on the changes in Low Isles (*Geogr. J.* 88 (1936) 383). Moorhouse's report will be found in *Reps. Gt. Barrier Reef Committee*, vol. 4, pt. 2, 1936, p. 37.

[2] With the possible exception of Eastern Hope Islet.

[3] *Reps. of the Great Barrier Reef Expedition*, 1928–9 (British Museum of Natural History), vol. 3, no. 2, p. 97, 1931.

younger in its stage of evolution than other islands such as Bewick or Enn (=N). Although it is larger and more impressive, it is probably younger than such small islands as Chapman, Sherrard, and Binstead Islands. It is doubtful if any great reliance should be placed on the stage which the sand cay has reached; the weather side of the reef appears to be the critical part. Two Isles is in a rather similar stage of development. True, the cay on this reef is perhaps the finest we saw, and is far more developed than that on Low Isles. On the other hand, the rather sketchy nature of the mangrove islet and the poor platform suggest that there is no great difference between the stages of evolution of these two islands.

If, then, an island is wanted as a standard of reference, Bewick or Enn (=N) is suggested. There are many similar ones, allowing for differences in reef shape, such as Houghton, Coquet, Hay, and Low Wooded Islands. But the compactness of Bewick and Enn and the good development of all their features lead the writer to adopt them as the most typical of the low wooded type of islands. Naturally, somewhat aberrant forms are found, *e.g.* some of the Turtle Group. Taken as a whole however it is remarkable how similar all these islands are, and they may certainly be regarded as a distinct class of coral island closely related to the special environment in which they are found.

12. Classification of the Coral Islands of the Barrier Reefs

Spender in 1930 put forward the following classification of reefs and low islands of all types that he knew on the Queensland Coast.

> Class I. Those reefs where the debris is scattered over the surface without forming a cay or rampart. Yonge reef, all the outer barrier reefs we visited, and, so far as is known, the majority of the outer barrier series fall into this class, together with a few of the inner reefs.
>
> Class II. Reefs bearing a sand-cay but no rampart. A few outer reefs and nearly all the inner reefs belong to this class.
>
> Class III. Reefs having sand-cay (immaterial whether or not vegetated) and rampart, but no vegetation on the rampart or flat. Since postulating this type of reef I (*i.e.* Spender) have found a reference to one example. The unique case is "B" reef, not far from the Hope Isles, and one of the reefs in the steamer channel exceptional in that it is not an "island-reef."
>
> Class IV. Reefs having sand-cay and ramparts: the rampart vegetated, but no distinctive vegetation on the flat such as the mangrove *Rhizophora*. None of this class known in the Barrier Reef region.
>
> Class V. Reefs having sand-cay, vegetated rampart, and mangrove swamp. These are the island reefs. . . .

This classification is based on an assumed difference of level of the supporting reefs. The general, not complete, absence of cays on the outer barrier is ascribed to its relatively low level, and the differentiation between inner-reefs and island-reefs is similarly explained. The statement that "the amount of emergence decreases from the coast towards the Pacific" implies an eastward tilt. A criticism of these views was made in a previous paper. As a result of my second visit to the reefs I still differ from some of Spender's explanations. A study of an outer reef was impracticable in 1936, but Spender's description is fully accepted. My own view is that the evidence of the benching and related phenomena, which are so widespread along the Queensland coast,

suggests that the whole reef area has been subjected to a recent eustatic movement in two stages, the one associated with the higher bench, the other with the lower.

Spender has shown from an analysis of tidal observations that the Low Isles reef is somewhat higher than some neighbouring inner reefs. It has yet to be shown that all low wooded reefs are higher than all inner or outer reefs. The impression gained by an extensive cruise and a study of the charts is that, while individual reefs vary a little in height, there is not sufficient difference between the reef zones in general for this to be the sole cause for cays forming on the lower reefs and low wooded islands on the higher. Detailed tidal observations alone can prove the matter, but the amount to which so many outer, inner, and isolated reefs uncover with the falling tide is from observation and chart evidence so similar that I feel that the degree of exposure of individual reefs is the most important factor in cay formation. This is supported by the fact that there are at least eighteen cays or sand-banks on the outer barrier north of the latitude of Cairns. If these reefs were effectively lower than the inner reefs, it is reasonable to suppose that their far greater exposure would have prevented cays from forming on their lee sides. Their presence is conceivably due in part to relatively high-level reefs which offer some protection. The reason that sand cays are common on the inner reefs and the low wooded islands on the isolated reefs in the steamer channel is here claimed to result mainly from the fact that the latter are sufficiently exposed to allow the "lagoon" waves to build ramparts and sand-banks or cays, whereas the somewhat greater shelter of the inner reefs prevents rampart building on them. The far greater exposure of the outer reefs however prevents the formation of shingle ridges because the ocean waves spread the coarse material as a layer over the reef surface.

A better example of the type of reef in Class III of Spender's classification is the small reef in the Turtle Group, referred to in Section 9 (*i*). Bee (=B) reef, as we saw it, vaguely comes into this class, but is not, now at any rate, a good case. Incidentally there are a number of reefs in the steamer channel which are not island-reefs, but several of them have sand-banks on them which are awash at high tide. I know of no adequate reason why islands should form on only some of such reefs. (But see last paragraph, Section 10.) The fact that there are examples of each kind should be recognized.

I am inclined to regard all[1] northern steamer channel reefs as potential low wooded islands; and the number which show sand and/or shingle awash at high water is an argument in favour of this point of view. Very small or long and narrow reefs usually seem to be least favourable to island formation, and, after all, general reasoning would eliminate these two types because their size or shape does not afford enough shelter for ramparts or cays to form easily upon them.

In Class IV the eastern Hope reef may be placed. Two *Avicennia* trees on the ramparts make them "vegetated," but there is certainly no *Rhizophora* on the flat. Sherrard Island nearly falls into this category.

I am, then, generally prepared to accept Spender's classification of reef types, but not the implication of the tilt suggested by his paper. In my own

[1] Excepting those obviously too deep below the surface.

view, accepting both higher and lower platform as raised, the movement which brought this about seems, as far as there can be any certainty in such matters, to have been eustatic. Different degrees of exposure, different sizes and shapes of reefs, slight differences of level of individual reefs, and many factors not yet understood are the more probable explanations of the several island types.

One further point calls for comment. How do the Bunker and Capricorn Islands fit into this classification? Many of these are true outer reefs, and some are shingle, some sand islands. True, the great depths outside the northern barrier are not found here. It is a problem which awaits full explanation, but the more variable winds, together with the very exposed nature of these islands, are important factors; and tentatively they may be related to the cays on the outer barrier in the north. They are quite different from the islands inside the northern barrier, and the fact that no definite evidence of any uplift was seen on them is consistent with the greater waves which can reach these reefs and pile up material to a considerable height to make the islands. But there is far from being an exact similarity of conditions over such a great extent of coral reefs as that bordering the Queensland coast, and this is one of the major difficulties in attempting any generalized explanations. Spender's classification applies to islands north of Port Douglas, and as such it stands, but it is not a comprehensive classification of the coral islands of the whole of the Queensland coast, and, as hinted in Section 9 (*m*), classifications carried into too much detail are apt to break down.

13. Summary

1. The Bunker and Capricorn Islands fall into two main groups: the shingle islands and the sand islands. Together they form an entity and cannot be considered as a part of the Barrier Reefs proper. No convincing evidence of recent vertical movement was seen on them.

2. Sand-cays may occur on almost any reef, but they are most typical of the inner reefs of the outer barrier. A number occur on the outer barrier. Those on the inner reefs are due mainly to protection from heavy seas and partly to the relatively high level of the reefs. Those on the outer barrier are ascribed on general grounds to the relatively high level of the reefs on which they are found. All are unstable structures and are not rigid in position and shape.

3. The lower bench is cut in rocks of varying hardness and structure. The corresponding platform on the low wooded islands is formed of coral conglomerate for the most part. Bench and platform are awash at high-water springs, but are here claimed as indicating a recent fall of sea-level of about 5 feet.

4. The higher bench is much more restricted, and in continental rocks is usually about 15–17 feet above low-water mark. High conglomerate platforms are found about 10–11 feet above low-water mark on the low wooded islands. They may possibly be correlated with the bench, but this is an open question. Certain conglomerate platforms associated with high islands are higher. Tentatively the remains of the higher bench and platform are ascribed to a eustatic movement earlier than that which led to the development of the lower bench. The total amount of movement for both levels is estimated very roughly at about 16–20 feet with respect to mean sea-level.

5. It is argued from field evidence that the lower platform of the low wooded islands is derived originally from a rampart.

6. Twenty-seven low wooded islands have been described. They are all on isolated reefs in the steamer channel between Port Douglas and Cape Direction. Their component parts are discussed, and the general conclusion is reached that the degree of exposure to which they are subjected (allowing for a slight recent negative movement of sea-level) is conformable with the development of ramparts, platforms, shingle islands, and cays. Not all reefs in the steamer channel carry this type of island, but the fact that many show sand awash at high water, and possibly some shingle to windward, renders it probable that, provided they are not too deep, all such reefs are potential low wooded islands. The less exposed position, but generally similar height, of the inner reefs is suggested as the reason why cays only characterize them.

7. Low Isles, the headquarters of the Biological Party of the 1928 Expedition, is shown to be somewhat different from most low wooded islands. Whilst this fact was fully realized by all members of the former expedition, it has been thought worth while to stress it here because Low Isles has necessarily become well known in geographical and biological literature.

8. Spender's classification of 1930 has been accepted for coral islands north of Port Douglas, but different views have been advanced in explanation of certain features.

In conclusion, I should like to thank Dr. H. Dighton Thomas for his help and criticisms during the writing of this paper.

APPENDIX

F. E. Kemp

In 1936 we knew what types of formations to expect in the reef area as a result of the work of the previous expedition. Our task was to bring back as much new information as we could, and to fill in the gaps left in 1928.

After the geographical section of the 1928 expedition had ceased to function as a unit Spender produced two maps which were models of accuracy. The map of Low Isles was constructed for the purpose of providing the scientists, who made that place their headquarters, with a reliable map on which to base their ecological work. Three Isles was mapped for a similar purpose. Part of Western Hope Island and several sand-cays were also mapped in 1928–29.

In the three months which the geographical expedition spent on the reefs in 1936, twenty-four sketch-maps of sand and shingle cays and fifteen of low wooded islands were made, as well as several sections. Most of the maps were made solely by means of a compass traverse, and therefore cannot approach the standard of accuracy attained by Spender in his maps of Low Isles and Three Isles. Various limitations were imposed upon the scope of our work. In the first place we had only three months to spend on the reefs and their great extent rendered it necessary to spend much of that period in travelling if we were to examine islands throughout the area. The tides also limited the time we had to work in. Spender has described how the tides on the Barrier Reefs show the influence of the diurnal constituents of the tide-producing forces and how "under certain conditions, therefore, one of the semi-diurnal tides will be considerably reinforced and the other sensibly masked." We spent our

time on the reefs in the months of May, June, July, and August, during which period low water occurs in the daytime. This was fortunate for us because it meant that practically the whole of the reefs were exposed in the daytime, but unfortunate in that this uncovering of the reefs only occurred once a day, and so we had to fit in our schedule of work with this as best we could.

Some idea of the nature of the islands and reefs we were investigating will have been gathered from Mr. Steers' account and illustrations. Practically all the islands, except the sand-cays in the earlier stages of development, were low and thickly vegetated, rendering triangulation difficult or impossible. Consequently some form of traverse was necessary. The sand-cays were easy to traverse and work could proceed at nearly any stage of the tide. The mangroves of the low wooded type of island however grow directly on the reef flat and it is possible to work round them for two or three hours only about the period of low tide. It is very easy to be caught by the rising tide and investigated by small sharks and sting-rays. A rapid method of survey was therefore necessary, and as our aim was to bring back reasonable physiographical representations of several of these complexes, a compass traverse was the only practicable means of accomplishing this. If we had attempted a more elaborate means of survey our work would have had to be very much restricted in its scope. Our expedition was, in some ways, in the nature of a reconnaissance, and a compass traverse gave us a physiographical map of an island in a few hours and so enabled us to see many more islands than would otherwise have been possible.

Plane-table and chain traverses were made of some of the islands, *e.g.* Heron Island, Lady Musgrave Island, Turtle I Island, Michaelmas Cay, and Masthead Island, and these are the more accurate maps. Heights were added to parts of these islands by Abney level and staff or by a builder's level. In this, as well as in the determination of the height above mean sea-level of the wave-cut benches, we were handicapped by the lack of suitable datum points, and so we had to use such criteria as the level of the reef-flat or the zone of *Ostrea mordax*. Our determinations were therefore usually approximated to the nearest foot.

The small open sand-cays, *e.g.* Sudbury Cay and the cay on Arlington Reef, could be mapped tacheometrically, a method used by Spender in 1928.

Note.

On the folding map accompanying the first part of this paper (*Geogr. J.* January 1937) the section of Cockermouth Island is rather misleading. The words "quartz sand rock" (see also p. 24) should refer only to the point indicated by the top of the arrow labelled "4 ft." I do not know for certain if the rock is a continuous layer as indicated by the dotted line.

Number VI, Turtle Island, in the present paper corresponds to number IV mentioned in the *Geogr. J.* 74 (1929) 255.

DISCUSSION

Before the paper the PRESIDENT (Professor HENRY BALFOUR) said: This afternoon we are to have a lecture from Mr. Steers on the "Coral Islands of the Great Barrier Reefs," which, as you know, form one of the most extraordinary features of the eastern Australian coastal area. The theme is so interesting that it is likely to provoke a lengthy discussion, and so, with a view to allowing time for that, I will make no further introductory remarks but call at once upon Mr. Steers to deliver his paper.

Mr. Steers then gave an abstract from the paper printed above, and a discussion followed.

The PRESIDENT: I hope that the extremely interesting communication to which we have listened will provoke discussion. Mr. Michael Spender has done a considerable amount of intensive research work in the region. We would like to hear what he has to say.

Mr. MICHAEL SPENDER: It is a great honour to be called upon to open this discussion, after a paper so interesting, lucid, and well delivered. The fact that Mr. Steers returned to the Great Barrier Reef indicated his deep interest in it, and because I recognize that this interest is so lively, I feel I can set to work to disagree with him on one or two points.

I have nothing to say about the Capricorn Islands, as I have never visited them. When Mr. Steers and I were on the Barrier Reef in 1928 we spent most of our time in the northern part, the part typified, amongst other things, by what at that time we called "island-reefs." Mr. Steers now prefers to call them "low wooded islands." They are nevertheless coral reefs. The "shore-party" in 1928, which consisted of Professor Stephenson, his wife, Mr. Tandy, Miss Manton, and, occasionally, Mr. Colman, formed a team; results were pooled and compared, so that the surveyor was forced to understand that a reef is a living organism and the biologist was made to realize that he must measure his environment. Each group kept the other group in mind. When I express any opinion it is that of the shore-party rather than my own.

It has been a great compliment to us and our work that Mr. Steers should have taken the problem up at the point at which we left it and tested some of our conclusions during visits to other islands. But from the start he shows by his simple choice of nomenclature that he still neglects the importance of coral and algae on these islands. Low wooded islands he insists on calling them, as though to suppress the really important fact about them that they are reefs. He actually criticizes our nomenclature by calling attention to some reefs near Howick island where the granite sticks through. Cays and mangroves have started growing on one of the reefs as a result of a slight drop in sea-level, and to describe the result as an island-reef seems to me nearer the mark than to describe it as a low wooded island.

Barrier Reef expeditions ultimately justify themselves as a result of the light they can throw on the problem of the Barrier Reef as a whole. That is why Mr. Steers has written much about levels. The study of up-lift and sinking, changes of sea-level, and so on, is one of the most important approaches to the general problem of the reefs.

The importance of cays tends to be over-rated in the present type of treatment because they are to be seen above high-water mark. But I must take up one point about them. In both of Mr. Steers' papers he describes the cays as "unstable." This is a misleading description. To a scientist "unstable" means that the cay, given a slight displacement, would vanish. Nothing of the sort happens. When the cyclone came to Low Isles in 1934, even that enormously displacing factor failed to prevent the cay from being rebuilt as soon as it had passed. A cay is, in fact, a perfect equilibrium structure due to the drift over the reef flat, the wave system of the lee of the reef, and the height of the flat. For that reason cays tell nothing of the past history of the reef but only of the actual momentary level of the reef. Calcification makes no real addition to the stability of a cay. However much vegetation binds the sand or beach-rock solidifies it, it will go quickly so soon as the conditions for its formation disappear. If an outer barrier reef were at a suitable level it would carry a cay. As Mr. Steers points out, eighteen of them do, which shows that they can. That the rest do not is because of their level.

The question of levels must be made clearer. The cay is an equilibrium

structure which forms at the lee end of the reef; on the weather shore there are those heavier banks of the coral shingle which is being broken off all the time from the living coral below the surface. The maximum growth of coral is at about 2 feet below datum line, that is to say, not far from the level at which Mr. Steers supposes benches to be cut on the mainland. This means that it is very unlikely if not impossible that a bench should be cut on a reef. Although the text is not quite clear on this point, it seems that when Mr. Steers identifies the "promenade" of the island-reef with the bench on the mainland, he means that the one was formed as a rampart at the time the other was being cut on the coast. This theory nevertheless implies that the rampart was formed at a time when the reef flat was 5 or 6 feet below its present level. Now the present level of Low Isles flat is measured as slightly above 4 feet above datum; and that of Three Isles seemed to be at a very similar height. I am quite certain that a rampart would never form on a reef flat at datum or slightly below it. At that height the debris would be swept over the flat and would not be checked to form a rampart.

I in my turn do not wish to imply disagreement with the postulated eustatic lowering of sea-level which has left its mark in this lower bench. I think Mr. Steers has made the case for this quite adequately. But it must antedate the formation of the features of the island-reefs. Conceivably there has been a slight lowering of the sea-level, something of an order of less than 2 feet, since the first ramparts were built, which is part of the explanation of the concreted rampart, call it former rampart or inner rampart as you will. But in any case Mr. Steers' lecture has seemed to me to show evidence of local changes of level, to be expected where lines of faulting are evident in the shore topography, amongst the islands themselves. The present state of affairs at Ingram and Beanley, for example, where the concreted rampart is being broken down and no outer rampart surrounds it, I would interpret as a case of local sinking, while possible other exceptionally high promenades are the results of local uplift.

The habit of physiographers to use terms like "less" and "more advanced" stages of development implies an evolutionary idea in this case to which I object. I have already expressed the opinion that the extent to which the mangroves cover the reef is conditioned by the momentary distribution of shingle on the reef. There is no reason to suppose that an island covered with dense mangroves is a "mature" form, because if the platform which protects them is, as Mr. Steers states, being eroded, the sea will eventually eliminate it and strip numbers of mangroves off the reef. As a matter of fact I am prepared to argue that that might have happened at Low Isles and has happened at Three Isles. At Three Isles the Third Island is probably simply the remains of a platform which ran round the whole island in the manner of several of the examples shown by Mr. Steers.

In conclusion, I should like to look ahead to future work. This study of the island reef has brought out certain anomalies between different reefs, and helped the general understanding of the problem. Future work must be directed to the main problem, that of the Barrier Reef as a whole. To that end I doubt whether deep boring should be undertaken again without preliminary prospecting, either with numerous shallow bores or with modern geophysical methods. I have consulted with some of the experts, Dr. Bullard, of Cambridge, and Dr. Brockamp, of Potsdam, and they agree that both pendulum gravity surveys and seismic soundings could be used in the conditions familiar to me in Queensland. These I think are likely to be the most profitable tools to use on this resistant strip of coral: and Lizard Island is a proper base from which to use them.

The PRESIDENT: Mr. Colman is here and prepared to speak as well as show a few slides illustrating some special points. I now call upon him.

Mr. COLMAN: It may be of interest at this point to call attention to some of the features of a coral reef on the other side of the world, surveyed by Mr. Tandy and me in 1931. This is a member of the group in the Gulf of Mexico known as the Dry Tortugas. The number of sand-keys (=cays) on the reefs of the group is liable to vary over a period of years; but at the time of our survey there were seven. The reefs which bear a sand-key, and on which there is no sub-aerial accumulation of coral-shingle, have a least depth of water of 3 feet. On one reef only the least depth is about 1 foot. This is taken to mean that the general level of this reef is some 2 feet higher than that of the others. This is the only reef in the group on which there is a shingle-rampart. The rampart was to windward of a sand-key on the same reef—a combination which recalled the features of an island-reef (=low wooded island). A survey [1] demonstrated that this first impression was well founded and that the system fulfilled Mr. Spender's definition of a Class IV reef. This identification was published in abstract and without details soon after it was made and before it had been worked up (*Proc. Linn. Soc. Lond.* 144th session, p. 59 (1932)).

I should like to emphasize that coral-reefs are biological phenomena first and geographical phenomena next. Our survey was primarily biological, and it showed clearly that in many corresponding places on Low Isles and on Long-Bush Key there were the same species of plants and animals, or closely related species of the same genera, leaving no doubt that the two reef-systems are ecologically homologous.

Long-Bush Key differed from a Class V reef (such as Low Isles or Three Isles) in two important respects. Most of the reef-flat remains covered at low water; and there is no mangrove swamp. In the region corresponding to the seaward edge of the mangroves of an island-reef however there are on Long-Bush Key between two and three hundred seedlings and young trees of the mangrove *Rhizophora Mangle*. Colonization to leeward over the reef-flat cannot happen because the depth of water is too great at present to allow the seedlings to ground and take root. It will be apparent that the absence of the mangrove swamp is due not to the absence of mangroves but to the comparatively low level of the reef-flat. The level of any part of a reef determines the kinds of animals and plants which can live on it, and alteration in level of a few inches will profoundly modify this population. If the level of the sand-flat at Long-Bush Key rises by as much as 1 foot enough territory will become available for mangrove colonization to make possible the conversion of a Class IV reef into a reef of Class V, the typical island-reef or low wooded island.

The PRESIDENT: The time has got on considerably, and so I will ask Mr. Steers if he would like to reply.

Mr. J. A. STEERS: Mr. Spender has raised several interesting points to which I should like to reply in some detail.

I have used the term "low wooded islands" instead of "island-reefs" because, for one thing, it has priority in usage. The islands to which both terms refer are all north of Cairns and are in a particular environment. This is explained in the paper. I quite admit that "island-reefs" equally well describes them, but "island-reefs" just as adequately describes the Bunker and Capricorn Islands. But the combination of sand cay, mangroves, and shingle ridges made up the units to which the name "low wooded island" was first applied. The Capricorn and Bunker Islands are quite different. Hence it seems better to restrict

[1] It is hoped that a detailed account of this will be published in a subsequent number of this *Journal*.

"low wooded islands" to the former class, whereas "island-reefs" could quite properly include the Bunker and Capricorns—and I think I am right in saying that these were not contemplated when the name was put forward.

I readily acknowledge the fact that reefs are "biological" as well as "physiographical" entities. But my work has been confined to the purely physical side. This is far from implying that the physical aspect is necessarily the more important. But I do feel that however important the biological aspect may be, it is right for a geographer to consider the *islands* as mainly physical structures. Calcareous algae, etc., certainly play an enormous part in their formation, but sand-banks and shingle ridges are first and foremost physical structures—and it is with these that I was primarily concerned.

Howick and similar islands are partly high islands, partly low wooded islands. I follow Mr. Spender's view in some ways, but where is the real distinction between an ordinary high island with a fringing reef, on the one hand, and an island-reef with but a relatively small mass of solid material and a large reef, on the other? The fact that mangroves occur on the one and not on the other can hardly be the decisive factor. General environment is of much greater importance, and the fact that I have included them as my last group in the low wooded islands means that I incline to class them together. All that is suggested is that whatever name is given to them, they are clearly not exactly the same as low wooded islands. Hence I prefer to group them separately, but ally them to my low wooded islands.

I think Mr. Spender under-rates the interest of cays. Throughout much of my account I have stressed the significance of cays or sand-banks; but because of their importance I have also given a separate section to them. A cay is only a bank above high-water mark. The use of the word "unstable" need not give rise to any difficulty. I used the word as meaning "apt to change or alter," or "not stationary," and Mr. Spender seems to me to make rather a finical comment. Reference to a dictionary will show that the word has a wide variety of meanings, and all that is implied in my account is that cays change shape or may be washed away and grow again in the same place, or at some other point (see Sherrard Island in text). Calcification may make no difference to a cay if we limit our meaning to his. But in actual fact beach-rock does make a difference, and a considerable one. Low Isles cay did not disappear in 1934: only comparatively minor changes took place, and in 1936 it had practically regained its 1928 shape. But I am not so sure that this would have been the case if there had been no beach-rock round it. Once again I will refer to Sherrard Island, where obviously the present cay is not where its predecessor was. Here the sand was apparently all washed out from the protecting beach-rock (which remains) and built up later alongside it. This clearly proves that a cay need not form precisely in the same place, and it suggests, but for obvious reasons does not prove, that if no beach-rock is present a cay can be swept away completely and rebuilt later in its original, or even a quite different, position.

On the question of benches and platforms Mr. Spender touches on a much more fundamental issue. I think it is clear in the text that a bench is cut and a rampart or platform built, and also that the platform is now being eroded on its exposed face as a result of a suggested slight uplift with respect to mean sea-level. I tried to be very guarded in the text, and I tried to give my reasons for the supposed shift of sea-level fairly. The reader must assess the evidence for himself. I believe that a slight negative movement has taken place and has given rise to the present platform, but I agree with Mr. Spender that there are many difficulties inherent in this hypothesis. The chief point, to my mind, is that the occurrence of the lower bench and platform over such an extensive area means a eustatic

movement. For this reason, amongst others, I doubt if there is much significance in Mr. Spender's remarks on Beanley Island, on which I do not think he has ever set foot. He may feel quite certain that a rampart would never form at datum or slightly below it, but that is rather a different matter from *knowing* that it will not. No one is more ready than I am to admit the difficulties in my hypothesis, but his somewhat sweeping assertion would apparently apply to any kind of off-shore bar—for there is, in some ways, no real difference between a shingle rampart on a coral reef and a shingle or sand-bar on any ordinary coast or island or slightly submerged rock, provided that the environment (*i.e.* depth of water, strength of winds, "fetch" of waves, etc.) is comparable. Much more detailed work is necessary to solve the problem, but I would ask him to visualize the whole problem of benches and platforms on the Queensland coast and reefs before he comes to a definite conclusion. I am far from being unaware of the many pitfalls besetting any one who interests himself in raised beaches, and field experience in a good many places has impressed upon me the difficulties of correlation. On the point in discussion I make no greater claims on my side than Mr. Spender does on his, but in addition to the detailed work he carried out, and which is of first-rate importance, I think he should also visualize the matter physiographically and as a whole. The actual amount of movement which gave rise to the lower bench and platform is tentatively put as about 5 feet: this is only a very rough estimate and will stand or fall as a result of future work. My object has been to try to gather together the various lines of evidence which seems to me to bear on the matter.

The extent to which mangroves cover a reef is not, I think, fundamental. I have suggested that their spread must depend on many incalculable factors. I would however suggest that the size of the shingle island, or the number and size of the various ridges, does measure a stage in the development of low wooded islands. I take it for example that Enn (="N") Island is for this reason in a more advanced stage than, say, Low Isles. That there are more mangroves on the former island is probably incidental, but it is not perhaps entirely incorrect to suggest that one reason is the far greater cover given to them by the greater development of shingle ridges.

Mr. Spender's last point is of very real importance. At this stage I do not want to say too much about it, although I am in full agreement with him. To my mind a bore is a chancy thing: it certainly will give precise details of the underlying material at one place. I realize full well some of the difficulties of borings and of the choice of site, and for this reason alone I should greatly welcome a geophysical expedition to the reefs. This should give some useful information of the probable depth of lighter material and therefore of the reefs' foundations, and so indicate the best places for bores. So far as I am able to visualize the whole problem I feel that only by geophysical investigations followed by boring will the vexed subject of coral-reef theories be settled.

[NOTE: I think the present development of obviously *new* islands on Pipon reef (apart from the main shingle island) is an answer to Mr. Spender's remarks about the Third Island at Three Isles. See also my remarks on Night Island.]

The PRESIDENT: All good things have to come to an end, and it is now necessary for me to bring the meeting to a close. At any rate we have had a most interesting afternoon, stimulated by an exceedingly clearly delivered paper admirably illustrated. It is however evident from what Mr. Steers has said and from what the further discussion has revealed, that the whole matter is still in a fluid state. It is evident that further research work will have to be pursued in that extremely important area. I can only express the hope that one result of Mr. Steers' paper will be to stimulate further investigations. It seems to me to call for a small

army of scientists, zoologists, botanists, physiographers, hydrographers, and the Admiralty Staff in general. I do not know who else would be required to complete the researches which are demanded, but the area is of such intense interest and offers so many varied types of interest that one can only hope that the research will be carried on continuously, and that, perhaps, Mr. Steers himself will be tempted to re-visit the area and conduct some further interesting work.

I ask you to express your appreciation of the paper and the extremely lucid manner in which Mr. Steers has given us what, after all, has only amounted to a very brief abstract of his printed paper. It is an exceedingly important paper, and we thank him for it.

A LINGUISTIC MAP OF WALES ACCORDING TO THE 1931 CENSUS, WITH SOME OBSERVATIONS ON ITS HISTORICAL AND GEOGRAPHICAL SETTING

D. TREVOR WILLIAMS

THE linguistic map has been based upon a series of County maps, drawn on a scale of $\frac{1}{2}$-inch to the mile, showing for each parish or borough the distribution of Welsh speakers (monoglots and bilinguals) as a percentage of the population, aged three years and over, in each unit. On the base maps the gradation is every 10 per cent. from 0–100, but on the map of Wales the intervals are spaced every 20 per cent. The limitations of such a map are obvious at a glance; the parish or municipal unit, in some cases, covers too large an area of varied structure and topography for desirable accuracy. The County Borough of Swansea for example extends 3–4 miles inland from the coast over an area in which the Welsh language is dominant, and yet the entire district is represented as one in which there are between 60–80 per cent. English monoglots. South, from Abergele, on the north coast of Wales, a long, narrow belt of anglicization is shown extending into the uplands, but the parish so represented, Llanfair Talhaiarn, has a population of only thirty-one individuals, aged three years and over, of whom seventeen are English monoglots. The writer has attempted elsewhere to overcome this limitation by personal investigation and survey in such areas and to demarcate, for the years 1933–35, a more accurate linguistic divide between the Welsh and English languages in these transition zones (1).

From Table 1 it appears that the counties of Anglesey, Caernarvon, Merioneth, Cardigan, and Carmarthen remain preponderatingly Welsh in language; Denbigh, Flint, Montgomery, Brecon, Glamorgan, and Pembroke are transitional in character, whereas Radnor and Monmouth are essentially English in speech at the present time. But our map makes it clear that the classification into English- and Welsh-speaking areas cannot be attempted satisfactorily from county statistics. Each transition shire has its Welsh and English divisions, the former tending to border upon the Welsh-speaking shires of the West.

TABLE 1. CENSUS RETURNS, 1931

County	*Age 3 years and over*	*Welsh only*		*Bilingual*		*Able to speak Welsh*
Monmouth ..	413,191	514	0·1 %	24,449	5·9 %	6·0 %
Glamorgan ..	1,166,998	9,129	0·8	346,244	29·7	30·5
Carmarthen ..	171,445	15,728	9·2	125,410	73·1	82·3
Pembroke	83,274	3,328	4·0	22,149	26·6	30·6
Cardigan	53,186	10,612	20·0	35,679	67·1	87·1
Brecon	55,153	1,104	2·0	19,443	35·3	37·3
Radnor	20,362	7	0·0	967	4·8	4·8
Montgomery ..	46,267	3,152	6·8	15,693	33·9	40·7
Denbigh	150,656	8,113	5·4	64,979	43·1	48·5
Flint	107,581	1,028	1·0	33,048	30·7	31·7
Caernarvon ..	116,013	24,873	21·3	67,024	57·9	79·2
Merioneth ..	41,311	9,113	22·1	26,431	63·9	86·0
Anglesey	46,940	11,231	23·9	29,813	63·5	87·4
Total ..	2,472,377	97,932	3·9	811,329	32·8	36·7

It is apparent also that the areas in which anglicization has been most complete include:

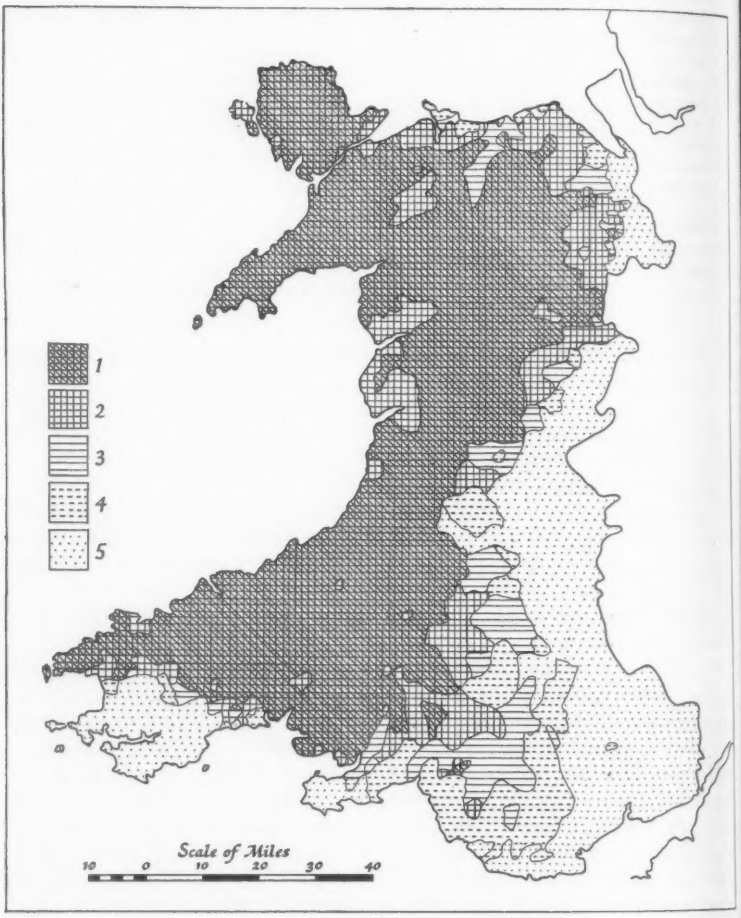
(1) South Pembrokeshire and the adjoining strip of South-West Carmarthenshire;
(2) the Gower Peninsula;
(3) the southern third of Glamorgan;
(4) the eastern Marchland, including Monmouth, eastern Brecon, Radnor, the Severn and Vyrnwy valleys in east Montgomery from Llanidloes to beyond Welshpool, the plain of Maelor in east Denbigh and east Flint; and
(5) the intermittent belt along the north coast between Prestatyn and Llandudno.

The upland of north and mid-Glamorgan remains a complicated linguistic area, and it is obvious that a Welsh-speaking enclave must extend into north-west Shropshire from the neighbouring shires of Denbigh and Montgomery.

The linguistic distribution map, compared with a topographical or structural map of Wales, exemplifies the influence of relief and geology upon the maintenance, or disappearance, of the Welsh language in different parts of the country. It is in the mountainous north, centre and west that the vernacular speech has survived to the present day, the peripheral lowlands both towards the east and along the north and south coastal plains have become areas of either partial or complete anglicization. Moreover, valley routeways from the border regions into the upland belts have been pathways of external contacts, more especially since the construction of modern roads and railways. English enclaves can be recognized in the upper Severn and Vyrnwy valleys in mid-Wales, along the Wye on the borders of Radnor and Brecon, and the Usk valley from the Gwent and Hereford plain upstream to beyond the town of Brecon. The process is discernible also in the coal valleys of Monmouth and Glamorgan.

It is customary to ascribe the first period of anglicization in the coastal lowlands of South Wales to the Norman and Anglo-Norman conquest and

colonization of the area during the twelfth to fourteenth centuries. The manorial régime of the Lordships-marcher with its alien judicial and land tenure systems was firmly established in South Pembroke, in Gower and in



Distribution of the Welsh language

Percentage of the population able to speak Welsh: 1. 100 to 80 per cent.; 2. 80 to 60 per cent.; 3. 60 to 40 per cent.; 4. 40 to 20 per cent.; 5. 20 to 0 per cent.

the lowlands of Bro Morganwg and plain of Gwent. The indigenous populations of these regions may not have been forcibly expelled, but the changed character of justice, religion, culture and economic life, associated with the castle and borough towns, would in time compel their descendants to master

the language of the new settlers. In Pembroke there were immigrants not only from Normandy and England but also from Flanders (especially in the hundreds of Rhoose and Castlemartin around Haverfordwest); its proximity to Ireland, and its economic and political connections therewith, facilitated Irish and Anglo-Irish settlements during the sixteenth century consequent upon the Elizabethan rebellions in Ireland.

In Gower and in the Vale of Glamorgan there is no historical evidence for large-scale Flemish colonization, but the mediaeval conquerors defended their acquired properties by the construction of numerous castles around some of which can be recognized the nuclei of future market towns and ports.

The anglicization of Monmouthshire and parts of Glamorgan is traceable partly to the Anglo-Norman settlement of mediaeval times, but mainly to the industrialization of the nineteenth and twentieth centuries. This new economic development reacted upon the northern hill country with its deeply entrenched valleys, a region of relatively low population density in previous centuries, and secondly upon the metallurgical and commercial ports of the coast.

TABLE 2.—POPULATION CHANGES IN GLAMORGAN AND MONMOUTH

	1801	1851	1901	1921	1931
Glamorgan ..	70,879	231,849	859,931	1,252,481	1,225,717
Monmouth ..	45,568	157,418	298,076	450,794	434,958
Swansea	6,099	21,533	94,537	157,554	164,797
Cardiff	1,870	18,351	164,333	200,184	223,589
Merthyr Tydfil ..	7,705	63,080	69,228	80,116	71,108
Rhondda	542 [1]	1,998 [1]	113,735	162,717	141,346
Newport	1,135	19,323	67,270	92,358	89,203
Abertillery ..	805 [2]	14,383 [2]	21,945	38,805	31,803
Ebbw Vale ..			20,994	35,381	31,686
Tredegar	—	8,305	18,497	25,110	23,192
Pontypool	—	3,708	6,126	6,881	6,790

[1] Ystradyfodwg Parish. [2] Aberystruth Parish.

The nature of this immigration into the two counties has been previously analysed (2). Naturally the largest proportion of the immigrants came from the agricultural areas of the two counties themselves and from the neighbouring Welsh counties; secondly from the English counties immediately to the east and southwards across the Bristol Channel; thirdly with the development of improved transport due to the railways, immigration occurred during the second half of the nineteenth century from more distant parts of the British Isles. The effects of the potato famines in Ireland and the periods of agricultural depression in England are clearly shown in increased immigration to the South Wales coalfield. In 1861 one in twenty of the population of Merthyr Tydfil was born in Ireland (4,265 from a total population of 83,875), and, for the same year, one in twenty-five of Swansea's population was Irish by birth (1,663 from a total population of 41,606).

This cosmopolitan population found English the natural medium of conversation and understanding. Elementary education after 1870, the English newspaper, scientific and other text-books written in English, trade union lodges and committees whose transactions were in the common language of most of the population, all increased the economic and cultural values of

that tongue although the aesthetic life, as shown in love of religion, music and the arts, has remained thoroughly Welsh in many industrial valleys in spite of the disappearance of the native speech of the Welsh.

The upper Rhymney Valley alone in Monmouthshire retains its Welsh language at the present day, and the great belt in central Glamorgan, lying between the lines—Swansea, Neath, Merthyr Tydfil, Rhymney on the north, Port Talbot, Bridgend, Pontypridd on the south—is in the process of linguistic transition. There are distinctly Welsh-speaking patches within it, but the general tendency is for the older people to speak Welsh, the younger to become English monoglots.

Along the eastern Marchland anglicization has been practically complete in eastern Brecon, throughout Radnor with the exception of the extreme north-west, the Severn Valley in Montgomery east of Llanidloes, and in those parts of Denbigh and Flint, east of Ruabon, Wrexham, Caergwrle, Flint (all inclusive). The anglicizing process relates to Norman and post-Norman settlements, to long-established economic contacts with the English border towns of Hereford, Leominster, Ludlow, Shrewsbury and Chester, and to more recent improvements in communications and transport. It seems that there has been a good deal of inter-marriage between Welsh and English along this frontier zone in addition to reciprocal migration of the farming communities. Welsh valley-ward movements of pre- and post-Norman times have left their mark upon the place-names of the entire march, but, even where there has been a comparatively late majority of Welsh speakers (*e.g.* in the Maelor lowlands of Flint, east of Wrexham, and as far as the lower Dee), the ultimate result has been the success of the English tongue. The Flintshire coalfield shows linguistic changes during the past one hundred and fifty years analogous with the changes that have occurred in the South Wales coalfield of East Glamorgan and Monmouthshire. The boundary between Denbigh and Shropshire dates from the mid-sixteenth century, and it is not surprising that, even to-day, a Welsh enclave extends within Shropshire west of a line joining Llanyblodwel–Oswestry–Chirk.

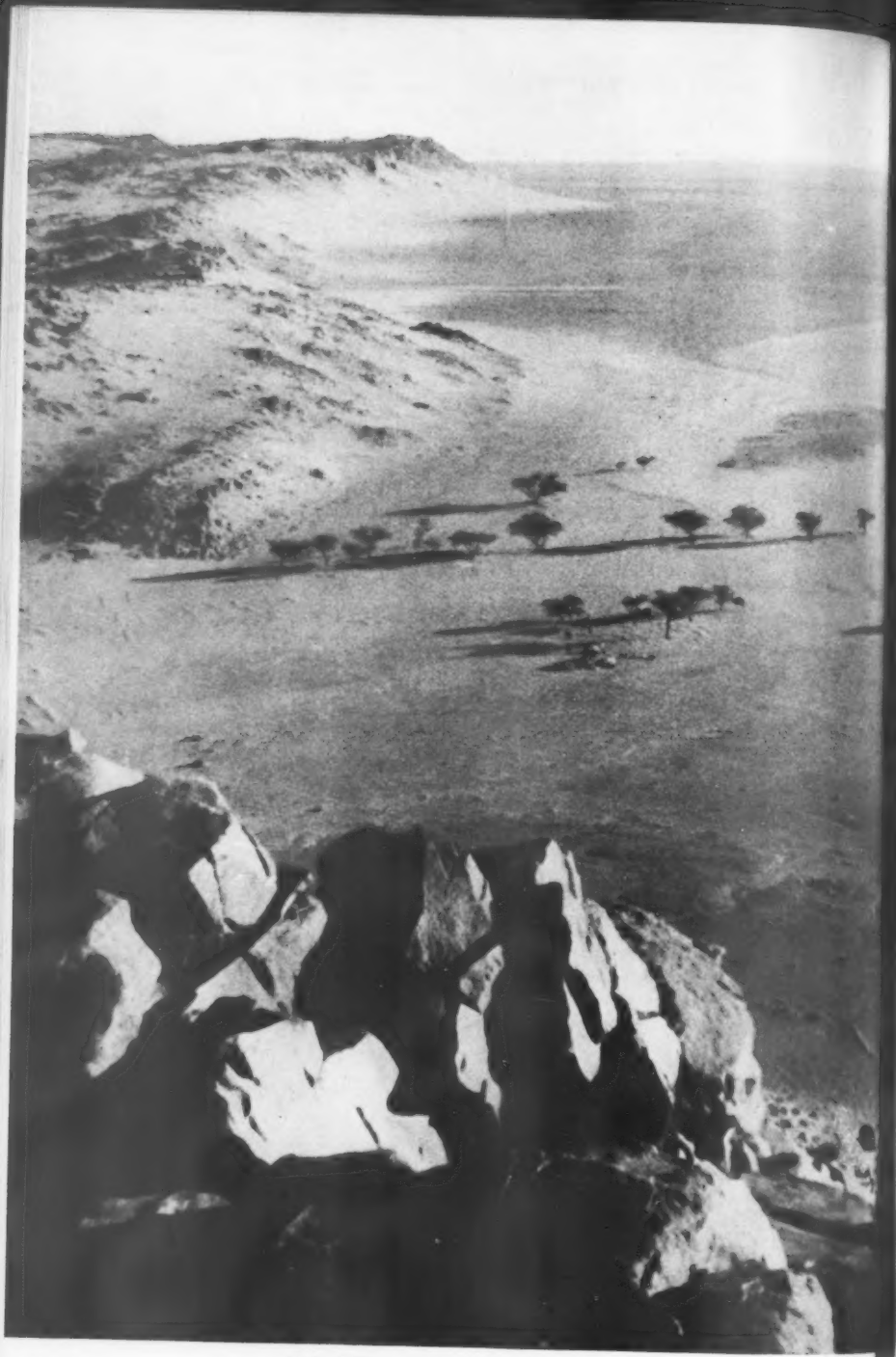
The anglicized coastal towns, from Prestatyn to Llandudno inclusive, are a nineteenth-century feature, related to their growth as tourist and holiday resorts and to the construction of the railway during the 'fifties to link up Chester with Holyhead and the sea-route to Ireland.

Finally, attention must be drawn to another linguistic map of Wales which was first published in 1926 by Mr. Trevor Lewis (3). Unfortunately, he does not state clearly the exact basis (whether parish or county statistics were employed) upon which his map was founded. Furthermore, it is not clear whether the index relates to Welsh monoglots only, or to Welsh monoglots and bilinguals combined. When this map is reproduced, as for example in 'Great Britain: Essays in Regional Geography' (4), and in a text-book on 'Europe,' by Valkenburg and Huntington (5), it is taken for granted that Lewis's map refers to combined Welsh monoglots and bilinguals, that is, ability to speak the Welsh language, amongst the population of Wales. Therefore, serious discrepancies are apparent in a comparison of the two maps, errors which are obvious to any one familiar with Wales and the Welsh people.

It is implied in these other maps that in the northern part of Glamorgan

Erg Shech

Azlef



Col of Tarit at the edge of the Tanezruft

0–10 per cent. of the population only is able to speak Welsh, whereas, in many parishes between 70–90 per cent. of the population is able to speak Welsh. Again, Carmarthenshire has 10–30 per cent. Welsh speakers according to these maps; but there are over 20 per cent. Welsh monoglots in this shire, and in most of it over 80 per cent. are able to speak the Welsh tongue. The perpetuation of such differences, which disappear if Lewis's map is taken to refer to Welsh monoglots only, conveys misrepresentations which may have far-reaching consequences upon historical and geographical interpretation of Wales, if allowed to remain uncorrected.

REFERENCES

(1) See *Arch. Camb.*, December 1935, pp. 239–66, and December 1936 (in press); Linguistic Divides in South Wales and in North Wales respectively. *Cf. Arch. Camb.*, December 1934, pp. 302–27; "Gower: A study in linguistic movements and historical geography," by D. Trevor Williams.

(2) A. E. Trueman, "Population changes in the eastern part of the South Wales coalfield," *Geogr. J.* 53 (1919) 410–19. Brinley Thomas, "The migration of labour into the Glamorganshire coalfield (1861–1911)," *Economica*, vol. 10, 1930, pp. 275–94.

N.B. In Table 2 statistics illustrate the decrease in population throughout most of the South Wales coalfield during the decade 1921–31 due to persistent unemployment and consequent migration outwards. This continuous emigration may intensify the economic need for ability to speak English rather than Welsh amongst the younger generation. On the other hand, it is difficult to assess the effects in the reverse direction of cultural and political nationalism as represented by the Youth Movement (Urdd Gobaith Cymru) and Welsh Nationalist Party (Y Blaid Genedlaethol).

(3) Trevor Lewis, "Sur la distribution du parler gallois dans le Pays de Galles, d'après le recensement de 1921," *Annales de Géographie*, Tome xxxv, 1926, pp. 413–8, map, p. 415.

(4) 'Great Britain: essays in regional geography,' by twenty-six Authors, ed. A. G. Ogilvie, second edition, 1930, map, p. 252.

(5) Samuel van Valkenburg and Ellsworth Huntington, 'Europe,' New York, 1935, map, p. 295.

NEW JOURNEY TO THE WESTERN SAHARA, 1935–1936

THEODORE MONOD

I DESCRIBED in the *Geogr. Journal*, June 1936, how I had to give up in the spring of the year 1935 the idea of crossing the central Tanezruft. I regretted this more especially as it was a vast, still quite unknown region, which left a sufficiently wide gap in our knowledge to preclude even general conclusions. Geological exploration of the area alone would permit a structural sketch of the Western Sahara to be made, by substantiating or by invalidating the hypothesis which I propounded last year concerning the eastern termination of the Arawan syncline.

On the occasion of my first visit to Taudeni I was struck by the trend of the Westphalian and Dinantian outcrops which spread out fanwise from a southern base and disappeared in the east under the intercalary Continental. I guessed that the same might well be the case with the other components of the Primary Series and that, in consequence, the Arawan syncline formed a loop to the north-east under the Tanezruft, as it formed one to the south-west on the Mauritanian plateaux. If this supposition were proved to be correct, it involved a prolongation of the crystalline ridge of the Eglab under the Tanezruft, the fusion of this ridge with the Central Massif and consequently a radical independence of the two great primary sedimentation basins of the west, namely, the syncline of Tinduf and the Tassilian basin in the north, and the synclinal trough of Arawan in the south.

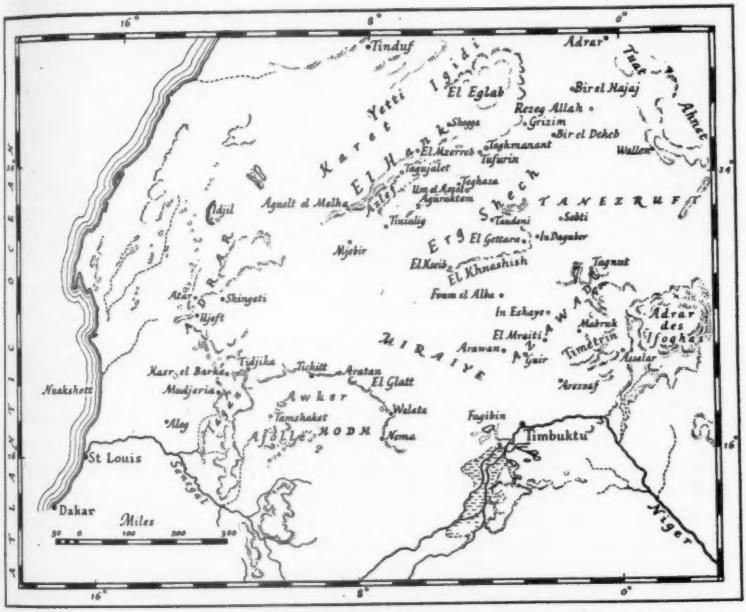
In the course of this winter I was able to complete my previous observations. In the month of November 1935 I proceeded rapidly to the intersection of the Trans-Saharan route and the Sudanese frontier, at which point on November 20 began the camel journey which was to end at Adrar (Tuat) on 18 March 1936. I proceeded first of all to Taudeni, *via* Tagnut and El Gettara, and then to Um el Assel, Tufurin and Mzerreb, at the edge of the Hank (15 December 1935). From there I pushed on to the north across the dunes of Igidi and the crystalline zones of Karet and Yetti, as far as Tinduf (December 25), crossing the Primary Series on the southern edge of the syncline of Tinduf. The return from Tinduf to In Daguber (27 January 1936) was made by a route farther east as far as Taudeni (Shegga, Tufurin, Taghmanant). On February 3 Lieutenant Brandstetter and I left In Daguber to cross the width of the Tanezruft by camel. On the 14th we reached the small Southern Algerian post of Wallen.

Geologically speaking, I was disappointed. From Sobti to Wallen, a distance of nearly 400 kilometres, there was not a single outcrop of crystalline rock; nothing but an enormous plateau *reg* resting on a *hammada* of Continental formation. The compact part of this *hammada*, which farther west (Hank, Igidi, etc.) appears only in the form of evidential fragments, must have had an edge which could be reached by marching west. We were consequently obliged to recommence the crossing in the opposite direction and to plunge into the Erg Shech, which we had to cross from side to side in order to discover finally, beyond Bir el Deheb, in the neighbourhood of Grizim, a

crystalline substratum of the *hammada* and the stromatolithic beds of the Hank. A study of the primary formations of the In Daguber/Sobti region, the north-western edge of the Ahnet, the "windows" of Rezegallah and Bir el Deheb and finally of El Aziri seems to establish satisfactorily the independence of the Southern Algerian and Sudanese primary basins and to bear out the hypothesis formulated in this connection last year.

From Bir el Deheb I reached Tuat again by way of Bir el Ḥajaj. Without going into further details, which will be recorded in a general work, I will confine myself to giving here succinctly the principal results of my last expedition.

1. *Stratigraphy*.—After cutting repeatedly across the northern edge of the



The Western Sahara

Arawan syncline and the southern edge of that of Tinduf, I was able to complete my previous observations. Various new fossiliferous deposits (Middle and Lower Carboniferous, Devonian, Silurian ?) have been identified.

The most important facts ascertained are first the discovery of a small coal flora (*Stigmaria*) in the sandstones and red clays of El Gettara-Taudeni, establishing the Westphalian age of this formation which, as I had already observed in 1934, but without the support of any palaeontological evidence at that time, constitutes the upper member of the visible part of the primary series and not the base of the intercalary Continental, which rests indifferently on terrain of the most varied character.

The second is the presence of what is undoubtedly Silurian at the southern

edge of the Tinduf syncline (Ordovician sandstones overlain by typical papyraceous Gothlandian clays).

Third is the unsuspected extension of the *hammadan* cover across the western Sahara. I was able to ascertain in fact that the *hammada* country of the Tinduf and similar types occupied not only the northern and north-eastern parts of the western Sahara but occurred also in the form of overlays, sometimes extending over enormous areas or dissociated into less developed patches, or even into mere bluffs, as in the central Tanezruft, below the Erg Shech and Igidi and over the Hank and the Azlef, etc.

This *hammada* often rests directly on eruptive rocks, which proves that the deposition did not follow the anticlines. These deposits, which are of uncertain age, perhaps Tertiary, like the intermediate Continental which they sometimes overlie, have filled the surface of a folded Primary with an already eroded relief, thus immobilizing and protecting a fossil morphology, the features of which emerge subsequently from beneath this cover in the course of an erosive cycle following the deposition of the *hammada*. The recent stripping of the *hammadan* shell gives rise to a petrified topography.

2. *Tectonic Features*.—The direction and the dip of the Taudeni Carboniferous outcrops led me to suppose in 1934 that the group of Palaeozoic formations at the northern edge of the Arawan syncline, far from running to the north-east to link up with the formations of the same age in Southern Algeria, must sweep round to the southward and isolate the synclinal trough of Arawan-Taudeni completely from the northern basins. This winter I have been able to verify this hypothesis on the spot, having found below the Erg Shech two Tassilian outcrops dipping to the north and at its western edge the prolongation of the Hank limestone, with stromatoliths, and of the Eglab eruptive rocks.

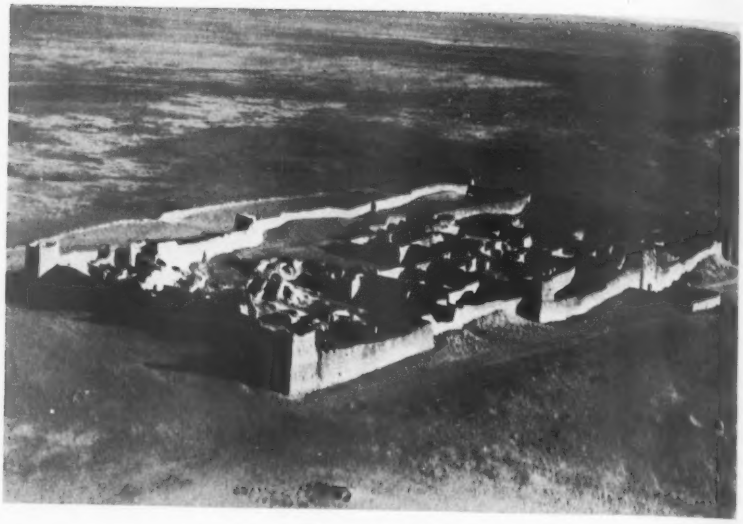
The Continental deposits quickly obscure the further course of these outcrops, but it now seems to be beyond doubt that the Arawan syncline ends in the north-east. The lack of connection between these two basins, the Algerian and Sudanese, which are separated from each other by the crystalline ridge of the Eglabs and their extensions, may perhaps furnish an explanation of the profound difference which they present at the base of the Primary series: that is to say, in the north a Tassilian scheme with Ordovician resting directly on Crystalline and, in the south, a *Hank-ish* scheme with a wide arenaceous-schistose-calcareous complex at its base below the typical Ordovician sandstones, of which the Mauritanian and Hank horizons with stromatoliths form part and which is perhaps, at any rate in part, Cambrian.

It may also be of interest to draw attention to (1) the Sobti conglomerate at the base of the Ordovician sandstones (consequently on a level with the basic conglomerate of the Lower Sandstones of the Tassilian basin); and (2) the probable existence of a gap at the base of the Devonian in the Taudeni region, where it would appear that the Middle Devonian rests on Ordovician, with an intermediate argillaceous horizon representing perhaps a more or less changed Gothlandian.

3. *The Tanezruft*.—The principal object of my last journey was to explore the central Tanezruft. Shortly after my departure from Sobti, in the direction of Wallen, the route ascends a bluff which is an extension of the Khnashish,

Sandstone at Makhruga

Rock of Z'ega near Aratan



Ksar of Taudeni

Edge of the Hank north of Tagujalet

the fate of which, east of In Daguber, has hitherto not been known. After the tableland is reached, it is found to continue as far as the first outcrops of the pre-Cambrian in the vicinity of the Trans-Saharan track. Over the whole surface of the plateau there is not a single topographical feature or even a wadi. The central Tanezruft, far from being a trough serving as a collecting area for wadis in the Quaternary period, is in fact a plateau. This was not previously known; indeed, the *reg* which covers it was believed to be a sure sign of recent alluvial origin. The Tanezruft gravel *reg* does not now appear to be transported, but a *reg* of disintegration, with gravel derived from a rocky substratum of very coarse sandstone conglomerate and released, one might almost say excreted, by the breakdown of the latter.

The complete absence on the plateau of any Quaternary lacustrine deposit supports the other observations. These deposits are numerous around the central Tanezruft, and it is precisely in the peripheral collecting zones that one must look for the terminal points of the large Quaternary wadis of Southern Algeria, which cannot be made to cross the *reg* and find an outlet in the Sudan. The *sebkha* of Taudeni for instance is an insignificant and purely local feature and can never have had any connection with the Middle Niger collecting zone or with the Algerian wadis by way of a hypothetical trough.

It is necessary to differentiate under the name Tanezruft, in the present European sense of the term, several natural regions: (1) A *hammada* Tanezruft of calco-siliceous outcrop and quartz gravels: an absolute desert which appears, even in prehistoric times, to have been given a wide berth by every one and never to have had any watercourses; (2) an argillo-gypseous and calco-marlaceous (neocretaceous-eocene) Tanezruft, forming small bluffs and low tablelands which are in many places greatly broken up: a region in which there was, once upon a time, water and which was visited; and (3) a crystalline Tanezruft, or properly Tanezruft-n-Ahnet, more to the eastward, through which caravans once passed.

4. *Prehistoric Features*.—Our search yielded plentiful results. Mention must be made in particular of the rich bifacial stone industries of Igidi and of the northern edge of Erg Shech, several Aterian specimens in Erg Shech and beautifully-made sets of Neolithic implements.

Various collections of drawings and paintings have been found. One of these, in a grotto, is of particular interest, in that it constitutes a pure collection of archaic type, without any admixture of the more recent Libyco-Berber, and accompanied by a local industry. This is one more proof of the true prehistoric age of these ancient drawings. In this collection were also found very interesting silhouettes of female subjects.

I must mention the discovery of a small meteorite in the Tanezruft, a small collection of botanical specimens, and numerous meteorological and hydrological observations. I visited the ruins of Tazadit and of Shegga in the Hank, where the house which had been reported to be the probable place of Davidson's death was found to be merely a Moslem tomb without any interest. I also found in the Erg Shech several fragments of ancient glass bracelets with welded threads, identical with those which are found in Teghaza and scattered along the old trade road from Tuat to the Sudan.

LAND UTILIZATION IN ENGLAND AT THE END OF THE EIGHTEENTH CENTURY

GORDON EAST

IT is a matter of both practical and educational interest to discover what possibilities exist for comparison between the present and the past uses of the land in England. Of the present utilization, thanks to the work of the Land Utilization Survey of Great Britain, we can and shall learn much. But how far is it possible to reveal the past conditions of land use? Hitherto attention has been drawn to two past periods[1] for which data are available, namely, the later Middle Ages, for which Domesday Book is the chief source, and the mid-nineteenth century, for which the tithe maps of parishes afford valuable and detailed material. It is the object of this paper to suggest that it is possible also to reconstruct, in sure outline if not in precise detail, the differential uses of the land in England towards the close of the eighteenth century. This work is possible because the literary and cartographical materials then available are more abundant and more fruitful than for earlier periods; further, it may well prove suggestive as a basis for comparison, since advances in agricultural organization and technique made English farming at that time both enlightened and prosperous.

Amongst the relevant literary material for the latter half of the eighteenth century, apart from the works of topographers who tended to copy from each other,[2] there are the able studies of rural economy, written by William Marshall, and the numerous volumes written or edited by Arthur Young. (These latter writers, in contrast to the topographers, were something like "field geographers," and wrote from direct observation.) In addition, there are a number of county maps, drawn on scales between $2\frac{1}{2}$ inches and 1 inch to the mile, the most remarkable and valuable of which are the surveys of John Roque.[3] Finally, the most important material of all, which has not received from geographers the attention it deserves, consists of the survey of British agriculture which was carried out, county by county, from 1794 onwards. This survey was sponsored by the Board of Agriculture and Internal Improvement, which was established in 1793 under the presidency of Sir John Sinclair and with Arthur Young as secretary.[4] The object of the survey, according to Sir John Sinclair, was to discover "the cultivation of the surface (*sc.* of the land), and the resources to be derived from it." The county reports are not, it is true, equal in quality or content. Some were based on

[1] See E. C. Willatts, "Changes in land utilization in the south-west of the London basin," *Geogr. J.* 82 (1933) 515–28; H. C. Darby, "The Domesday geography of Norfolk and Suffolk," *ibid.* 85 (1935) 432–52; and H. K. Henderson, "Our changing agriculture: the Adur basin, Sussex," *Journal of the Ministry of Agriculture*, vol. 53 (1936) 625–33.

[2] *Cf.* G. E. Fussell's "Agriculture and economic geography in the eighteenth century," *Geogr. J.* 74 (1929) 170–78.

[3] Thus Roque's survey of Berkshire, for example, covering eighteen sheets and drawn on a scale of nearly 2 inches to the mile, shows in considerable detail the various uses of the land in 1761.

[4] On the origin of this Board, see *Annals of Agriculture*, edited by Arthur Young, XX (1793) 204–13; and XXI (1793) 129–50.

actual surveys, for example, Thomas Davis's report on Wiltshire; others, like Billingsley's 'Somerset,' were based only on the collection of local experience and information. In every case something is given about soils, this usually forming a section of the report; in some cases, too, the account of farming in its various departments is carefully related to the natural regions within the county. Again, some of the reports, about one-third, are the more valuable since they contain maps. These maps, although clearly no uniformity of presentation was agreed upon, were usually attempts to indicate, in a generalized way, the distribution of soils, but sometimes they show broadly the actual utilization of the land, whether for arable, pasture, woods, or orchards.

No attempt can be made here to outline the uses of the land throughout England towards the close of the eighteenth century: the aim is merely to sketch for three selected counties—Middlesex, Wiltshire, and Somerset—the conditions which then obtained and to note the apparent geographical correlations. It is well however to recall very briefly some of the salient features of the English countryside at this time. In the first place, the process of enclosure, which had long been operative, was transforming the face of lowland England. By the end of the century, with the exception of extensive highland tracts in the north and west and of certain backward agricultural lands in the midlands, the countryside had become, almost alone in Europe, a chequer-board of enclosed fields: it had largely assumed the pattern which characterizes its surface at the present day. Secondly, the progress of enclosure was associated with the "New Husbandry"—with the introduction of new fodder crops, new rotations, and new methods generally. These new ideas, which had entered England from the Low Countries from about 1650 onwards, were applied—unequally it is true—in many parts of England, in response to the growing demand for food supplies for a rapidly increasing population. In consequence the eighteenth century witnessed not only the reorganization of existing arable and pasture lands, but also an increase in the area of farm land at the expense of woodland, downland, heath, and fen. It is not possible to state with any accuracy just how much land was pasture or arable, since the available estimates await critical scrutiny,[1] but Sir John Sinclair calculated the area of commons and waste land in England and Wales, on the basis of the county reports, at 7·8 million acres, that is about 20 per cent. of its area.[2] If Gregory King's figure for 1696 may be taken as a rough clue to the conditions which then obtained, considerable advance in the profitable use of the land may be inferred, since he classified as "heaths, moors and barren lands" some 10 million acres. It must be added that this figure appears too low: some of the commons for instance included by King in 3 million acres of "forests, parks and commons" may well have been almost waste land. Further, Sinclair's figure for the area of waste deserves careful examination: one expert[3] believes it "probably a gross under-estimate."

[1] Sinclair's estimate (*Annals of Agriculture*, XXI (1793) 132) of the acreages of "grain land," "pasture land," and "waste or under a defective system of husbandry" in Britain in 1793 had no sound factual basis.

[2] *Report to the Committee of the Board of Agriculture* (1795). See also on the waste lands of Britain the acreages given for each county in *Annals of Agriculture*, XXXIII, (1799) 12–59. These figures await critical handling.

[3] Lord Ernle, 'English farming past and present,' 4th ed., 1932, p. 152.

Middlesex

Middlesex provides an excellent instance of an area where drastic changes in the use of the land have taken place since the eighteenth century. Already in the 1720's Defoe described it in his 'Tour' as "a country made rich, pleasant, and populous by the neighbourhood of London." Outside the small built-up area in and around the City and Westminster villages were increasing in size and population, since business men sought residences on the rural outskirts of the City, whence they made their way by coach. In 1794 Peter Foot names seven market towns besides the capital: Uxbridge, Brentford, Enfield, Barnet, Staines, Edgware, and Hounslow. Beyond the City and Westminster,

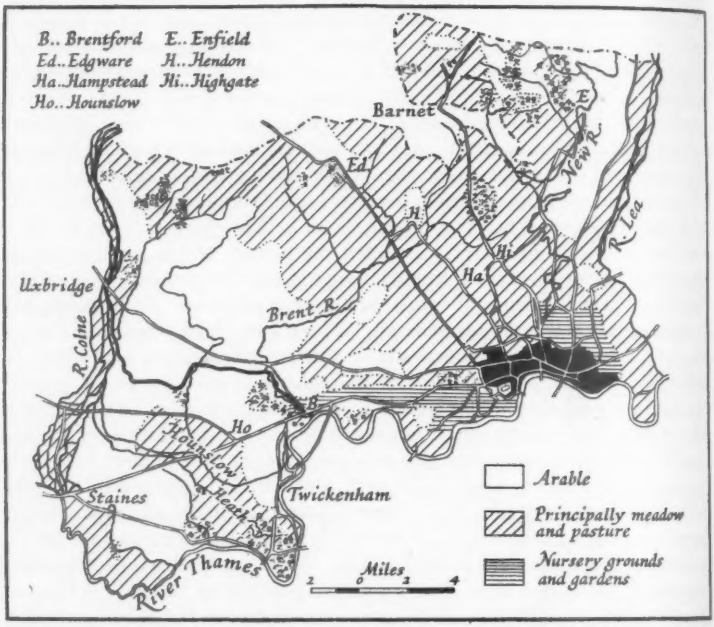


Fig. 1. Land Utilization in Middlesex. (Based on John Middleton's map, 1798.) The Grand Junction Canal is shown

buildings had then spread on all sides over the Taplow Terrace gravels, especially in the west, as far as Hyde and Regent parks.[1] But elsewhere and characteristically Middlesex remained a rural region devoted to agricultural pursuits. The uses to which its lands were put at the close of the eighteenth century are revealed in some detail in the agricultural reports of Peter Foot and John Middleton in 1794 and 1798 respectively, and in William Marshall's 'A Sketch of the Vale of London and an Outline of its Rural Economy' in 1799. The map, first published by Foot and later included, with only small

[1] See L. Gomme's map, showing the growth of London between 1560 and 1887, in *Geogr. J.* 31 (1908) 588.

amendments,[1] in Middleton's report (see Fig. 1), is a remarkable if crude anticipation of the utilization maps of to-day. It is clearly, in its attempt to give a generalized picture, a genuine "geographer's map," and it represents a type superseded shortly afterwards by the earliest Ordnance Survey maps. The scale is 4 miles to the inch; the different uses of the land are distinguished by water-colours, or, in the case of heath, parks, and woods, by appropriate symbols; the boundaries of the hundreds, into which the county was divided, are shown in red lines; and finally, rivers, roads, and chief settlements are marked and named.

It is worth while reviewing briefly the varieties of soils and their disposition in Middlesex, in order to discover to what extent this factor explains the differential uses of the land. The reporters to the Board of Agriculture, in their descriptions of the types of soils and their distribution in the country, use terms which are substantially those used by geographers to-day. The commonest soil in Middlesex, which was extensively spread to the west of the New River and to the north of the London–Uxbridge road, was a heavy clay, developed on a tract of London Clay. "In Middlesex," wrote Middleton, "it (clay) is called ploughing up poison"; it is "the most tenacious, obdurate and ungrateful soil known." Nor could he agree with those who styled the clay land in Middlesex "prolific," since it was "naturally tough, gluyey, wiry and sticking to everything . . . while wet," and assumed "a stony hardness when dry." In sharp contrast to the clay ("bean soil"), sands and gravel, together with some loam ("turnip and barley soil"), covered many hilly areas, such as Hampstead Heath and Enfield Chase. Further, intermediate between impervious clays and the lighter porous soils, were others variously distinguished as loamy sand, sandy loam, strong loam, and loamy clay. It is sufficient here to note that "loamy-sand" so-called, overlying river gravels, was distributed in the south-west of the county, and again over the terrace which stands above the Lea valley and extends northwards from the City. Similarly, sandy loam covered the Taplow Terrace, which overlooks the Thames between Chelsea and Twickenham. Again, loams, this time "strong loams," occurred in two areas: in the east, between Islington, Highgate and Hornsey; in the west, between Ruislip, Harrow, and Greenford. Finally, there was a little alluvial marsh, especially in the Isle of Dogs and along the banks of the Lea and Colne. In short, the small area of Middlesex contained not only much heavy clay but also almost the whole gradation of English soils, as these were roughly classified in farmer's terms. Middleton exaggerated somewhat, yet emphasized an important point, when he wrote: "The top soil has everywhere been ameliorated or changed by the operations of the elements, by manure and cultivation; these powerful agents have made the surface of all the lands in this country assume, more or less, the appearance of loam." So much for the soil cover of Middlesex: the question now arises: to what extent were the differential possibilities of these soils reflected in the eighteenth-century agriculture of the country?

Correlations between the kind of soil and the use of land are in many cases

[1] Thus Middleton added the Grand Junction Canal, but omitted, through error, to show the market gardens and orchards between Brentford and Twickenham. In the 1808 edition of his Report Middleton added hachures to this map.

striking, but it is important to avoid exaggeration. Farming in Middlesex certainly failed to reach the levels of the best-farmed counties of the time, such as Norfolk, Suffolk, and Leicester. It preserved many residuary features of traditional organization and methods, despite the advances which were taking place elsewhere in the art of farming. William Marshall, writing in 1799, went as far as to state: "A considerable portion of the lands of this Vale (*sc.* of London), even within a few miles of London, remain in the same state of nature and neglect as that in which they were found by the first inhabitants, and in which they lay, on the day of its foundation." This was an exaggeration, and it is certain that the presence of London, the greatest market in the country, exerted an economic influence on agricultural activities in Middlesex, an influence which, in some measure, masked the distinctions between soils.

To cite one instance, it is clear that both the character of the soils and the proximity to the London market combined to condition the cultivation of fruit and vegetables on "the excellent dry loam" north of the City, between Stepney, Hackney and Islington, and westwards of Westminster, between Chelsea and Twickenham [1] (see Fig. 1). The orchards were stocked with an "upper crop" of apple, pear, cherries, plums, walnuts, etc., and an "under crop" of small fruits—raspberries, strawberries, gooseberries, and currants—which could grow beneath the shade of the "upper crop" trees. The market gardeners in these areas made plentiful use of dung, brought from London, and, in some cases where their land lay within the alluvium of the Thames, irrigated it with river water. A wide variety of vegetables, including salads, was grown, testifying incidentally to the increasing consumption of vegetables in eighteenth-century England.

It was land devoted to meadow and pasture which bulked largest in the 1790's (see Fig. 1). These were, for the most part, the heavy clay lands, "untractable and ill-calculated for the plough," and smaller areas of alluvial meadow along the Lea, the Colne and the Thames, especially in the Isle of Dogs, where ditches and a river embankment served to keep it sufficiently dry. The grasslands of the county consisted above all of mowing grounds and cow pastures, producing hay and milk for the London market.[2] Cow-keepers were "engrossing" all the land they could procure immediately around London, and stocking it with cattle from Staffordshire, Lancashire and Yorkshire.[3] By a careful computation Foot showed [4] that 8500 cows were kept for the supply of milk to London, of which 7200 were kept in Middlesex, 691 in Surrey, and 681 in Kent. He showed, too, in some detail, where they were pastured in Middlesex—in fields, adjacent to Westminster and the City, now covered with buildings and streets. Proximity to London governed also farming practice in the grasslands. At a distance from London, Marshall noted, land was used in alternate years for hay and for pasture, since it was necessary to feed cattle on it periodically in order to preserve its quality. Nearer town, in contrast, where night soil, stable manure, ashes, soot, and

[1] Middleton, 'View of the agriculture of Middlesex' (1798), pp. 254–72. See also S. Lysons, 'Environs of London' (1792–6), IV, pp. 574–6.

[2] Marshall, 'A sketch of the rural economy of the vale of London' (1799), I, pp. 36–52.

[3] *Annals of Agriculture*, XXI (1793), 112–17, and 526–33.

[4] 'General view of the agriculture of Middlesex' (1794), pp. 80–83.

woollen rags could be got cheaply in large quantities (did not London appear to Arthur Young as a dunghill ?), there was no need to resort to this practice, "town manure being depended on for keeping the lands in a state of luxuriance." [1] This was usually the case in "the grassland townships of Marybone, Pancrass, Islington, Highgate, Hampstead, and Hendon," where the ground was "strongly manured." The hay season in Middlesex caused the immigration of seasonal labour from Ireland, Wales, and northern England; when cut, the hay was brought to the four hay markets of London: to that of St. James's in Haymarket which served the West End; to that at Whitechapel for the East End; and to Smithfield and Borough Markets for the City. A subsidiary industry in the hay country around Hornsey, Finchley, Hampstead, and Highgate, was "suckling sheep for house lambs," which suggests that Londoners, anticipating present-day tastes, already appreciated lamb, as distinct from mutton.

It is worth noting that the large area under grass in Middlesex, representing about a half of the extra-metropolitan area of the county, marked the conversion of land formerly wooded or arable. Middleton recorded that many pastures bore traces of previous ploughing.

In addition to the meadows, pastures, and market gardens, Middlesex included arable fields, which covered rather more than a third of its area. These stood, for the most part, between the Colne and the lower Brent, and along the terrace above the valley of the Lea. In part, these ploughed fields lay in tracts of loam soils, well suited for cultivation, given the technical knowledge of the time. In contrast, in north-west Middlesex, north of the road between Hounslow and Colnbrook, the arable fields covered a region of heavy clay soils, which at best, as on its eastern margin, were "strong loams." These soils, in north-west Middlesex, although potentially good for wheat, were certainly difficult to work. The arable husbandry of the county fell far short of the best practices of the day; the open-field system still survived throughout almost all the arable land of north-west Middlesex. It is clear that wheat had been grown there at least since the reign of Queen Elizabeth, for John Norden, in his 'Speculum Britanniae' (1593), remarked on "its excellent good wheat," and, further, epitomized the difficulties of arable farming on the London Clay:

> "The deep and dirtie loathsome soyle
> Yields golden gaine to paneful toyle."

Moreover, north-west Middlesex was a curiously remote area, avoided by the main highways from London; standing water on the clays made its local roads often impassable, and it lay too far away to benefit from supplies of manure from London. In fact, this area remained arable only because the common field system still survived, and Middleton believed that if this had been abolished the land would have been worth more for hay. It is not surprising that arable farming was more advanced on the light loams to the west

[1] Up to about 1750 inns and livery stables paid farmers, who brought hay and straw, for taking away their dung. Subsequently a price was charged for these, amounting in 1799 to two shillings a load, but at this price they were reckoned cheap. Marshall, *op. cit.*, I, 31–32.

of the New river. "The most fertile part of this county," wrote Middleton, "is within eight or ten miles of the metropolis, and that improved by the advantage of manure." The arable farmers in the east of the county, well placed in this respect, were chiefly employed in raising wheat crops for the London market. In the carriage of this grain, as also of fertilisers, the river Lea played some part, and Enfield was connected with the City by one of the earliest turnpike roads.

Commons and woods occupied a relatively small proportion of the county: scarcely one-eighth c. 1800. The two largest areas of commons were Hounslow Heath and Enfield Chase, but much of the latter had been enclosed for arable in the 1770's. In addition there were a number of smaller tracts, such as Harrow Weald, and Finchley, Ruislip, and Sunbury commons. These commons occupied soils of all kinds—loams at Hounslow Heath, clays at Enfield Chase. For the most part they were covered with furze and heath, which offered a little poor firing; perhaps one-third of their area provided meagre grass for pasture. "The copses and woods of this county," wrote Middleton, "have been decreasing for ages": in fact, they covered barely 2 per cent. of this formerly well-wooded county. The biggest single tract stood on the clays, on the north-west side of Ruislip; and there were fragments of woods on the eastern side of Finchley Common, in Enfield Chase, and on the northern slopes of the Hampstead and Highgate ridge. The woods included young elms and oaks; old mature timber trees seem almost entirely to have disappeared. In general, contemporary critics were agreed in condemning the condition into which both the commons and woodlands had fallen. "Most of the ancient parks are disfigured with trees that are mutilated, ruptured, and rotting as they stand," and hedgerow trees were severely pollarded owing to the scarcity of wood fuel.[1] Similarly the commons, neglected and undrained, were described as "in a state that would be disgraceful to the most recluse part of the Island." Far from providing profitable timber or good pasture, the uncultivated lands of Middlesex were noted rather as "nurseries of thieves," and as "rendez-vous of gypseys, strollers, and other loose persons, living under tents." It is not surprising that many agriculturists urged the conversion of the commons and woods into productive pastures by means of enclosure, draining and improvement of the soil.

In short, the land utilization of eighteenth-century Middlesex represents one distinctive phase in the sequence of ever-changing landscapes, which have been continually shaped by human agency. In that century the greater part of the county was applied to various agricultural purposes—especially hay production. This specialised activity was localized in Middlesex largely as a result of two economic facts: the many horses used in London needed supplies for food, and the carriage over long distances of such a bulky product as hay was relatively costly. Only a small part of Middlesex was covered by buildings, or remained under wood, heath, park, and commons. The Land Utilization Survey's map of Middlesex, now available on a scale of 1 inch to the mile, presents a picture greatly changed, above all by the expansion of Greater London. But the full implications of the present utilization and the

[1] Bakers in London, as Marshall noted, were no longer using faggots but coal in the latter half of the eighteenth century.

degree to which it still embodies features of the late eighteenth century must await the full report now being made.

Wiltshire

Thomas Davis, who reported on the agriculture of Wiltshire in 1794, showed that, on grounds of physique, soil and economic productivity, the county was divisible into two contrasted parts by an irregular line along the foot of the chalk hills from the north-eastern to the south-western end of the county. South Wiltshire, commonly called the Wiltshire Downs, was "a broken mass of chalk-hills, which . . . terminate in bold breaks running from the north-east to the south-west side of the county," and its "general appropriation" was to corn husbandry and sheep walks. It was, in fact, the granary of the county, supplying not only the many industrial towns of Wiltshire—where many textile industries still flourished—but also those of eastern Somerset, as well as Bristol and Bath. North Wiltshire, on the other hand, contained "a rich tract of vale land, stretching north-east and south-west through the county, under the foot of the chalk hills, but rising gradually north-west." This tract included two distinctive areas. First, "a tract of rich grazing land, on the banks of the lower Avon and the Thames," famous for its dairy produce, especially cheese. Second, what was "undoubtedly the most useful land in the district," the Vale of Pewsey and a strip of lowland between Chippenham and Cricklade, in both of which a subsoil of "sand veins" bore deep sands and sandy loams, well adapted to cultivation by the plough and the spade. On the basis of its varied physical endowment, Wiltshire farming, even if it preserved traces of outworn and inefficient agrarian organization and methods, produced a variety of products which more than met the needs of its own population. Moreover, thanks in part to its industries, eighteenth-century Wiltshire was a relatively populous region, and its local markets, together with that of London and those of east Somerset towns, stimulated farming: "Good markets," wrote Davis, "make good farmers."

The map which accompanies Thomas Davis's report is one of the best of the generalized utilization maps of the time (Fig. 2). It distinguished in colours land which was chiefly arable, land chiefly pasture, the downlands (which were natural pasture), water meadows, and lastly "woods and wooded parts." The map is thus a useful starting-point from which to discuss the utilization of the county.

Davis provides scarcely any figures to show the acreage of the land put to different uses, but it is clear that land devoted to grass, whether it was hill pasture, enclosed grass land in the plains, or water meadows along the river valleys, bulked largest in the rural economy of the county. In south Wiltshire the grass lands consisted of the open downland and of water meadows, both of which were used seasonally for the pasturage of sheep. Two types of land, distinguished by their soils, occurred on the Wiltshire Downs. One was "the red land," occupying generally the tops of hills, "a deep, strong, cohesive, sour land, with an intermixture of flint, over solid chalk": this was covered largely by furze and stunted thorn bushes, its forests having almost disappeared. The other was "the black land," which had a cover of loose, black, peaty soil over a bed of flints or rubbly chalk: this usually shallow soil covered

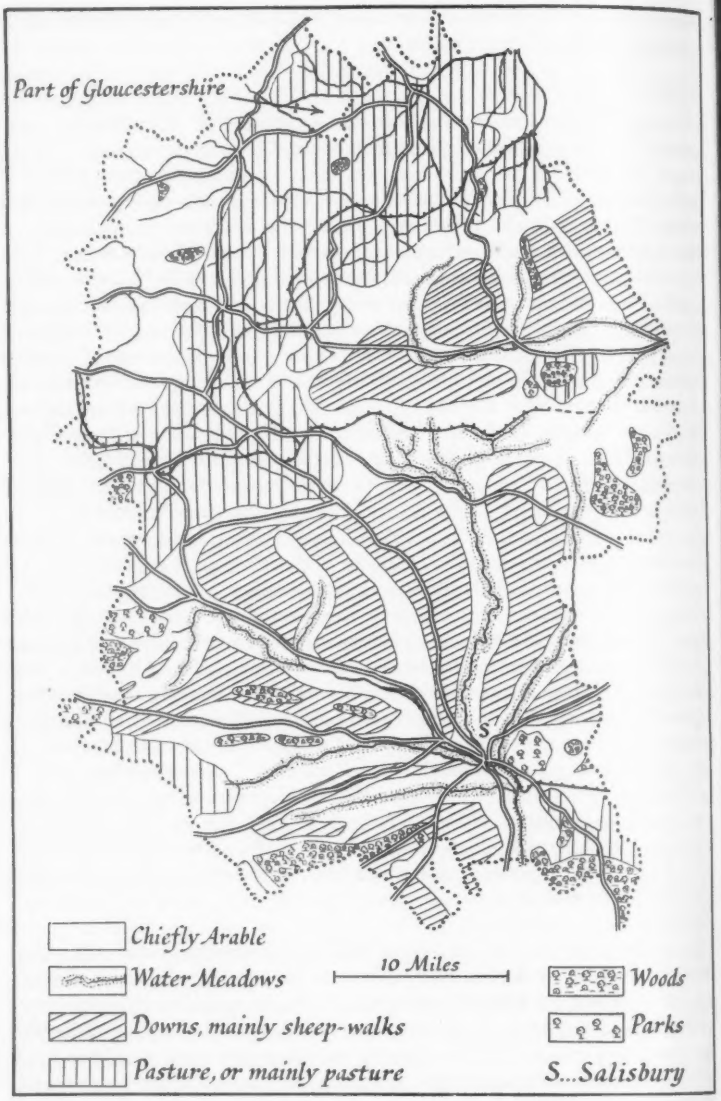


Fig. 2. Land Utilization in Wiltshire. (Based on Thomas Davis's map, published first in 1794 and, with slight modifications, in 1813.) The canals shown linked up the Kennet, Avon, and Thames

the sides of the downs and the valleys, and bore "the sweetest feeding part of the Downs." The Downs provided for sheep in summer a varied natural herbage, which was kept "sweetest" by treading and close feeding.[1] The summer pasturage of the Downs was supplemented at other seasons by meadow grass or hay. Irrigated water meadows covered an area of 15,000 to 20,000 acres in south Wiltshire (*e.g.* along the Avon), and their regulation was managed with much art, for which the county was famous.[2] Irrigated meadows were either "catch-work meadows" on valley sides or "flowing meadows" adjoining rivers. In both cases the ground was thoroughly soaked at certain times and then dried, channels being made to carry on and carry off the water supplied by springs or rivers. As a result, and this was the great advantage of water meadows, they provided good early feed, in late March and April, for the ewes and lambs: a great advantage, for south Wiltshire, standing fairly high and exposed, was "a cold and late springing district," and supplies of hay did not last until the hill pastures were ready. After they had fed the ewes and lambs, the meadows were watered, and "laid up for hay"; finally, in the autumn, after the harvest, although too wet for sheep, they provided grazing for dairy cows, until it was time for the "winter watering."

The grass lands of south Wiltshire supported a large though decreasing number of sheep, which were mainly the horned Wiltshire breed, although South Down sheep, producing finer wool, were introduced from 1789 onwards. The whole summer stock of sheep (including lambs) in south Wiltshire was estimated at half a million, and it was reckoned that 150,000 lambs were bred yearly: wedder lambs were fattened for sale in the autumn at Weyhill. In north Wiltshire the pasture lands, which were chiefly enclosed fields, but included also some open commons, much exceeded the arable lands in area and were devoted to cattle, the chief objects being the production of cheese and veal, and to a lesser extent bacon and mutton, for local and distant towns. The pasture belt of north Wiltshire extended south-westwards from the Thames to beyond Trowbridge: to the east of it rose the escarpment of the Downs, to the west of it lay an upland arable tract on the Great Oolite formation (see Fig. 2). William Marshall, who had a keen interest in regional analysis, noted [3] that the north Wiltshire pasture vale formed part of a wide "Dairy district" (largely coincident with the Oxford Clay) which included parts of Berkshire, Gloucester, and eastern Somerset. In the Wiltshire section of this tract the soils were for the most part deep and impermeable, but there were local variations: in the south between Chippenham and Trowbridge, though deep, the soils were fairly well drained, whilst northwards from Chippenham to Cricklade there were some good sandy soils. Generally, although old roads were often impassable, turnpikes brought some improvement, and the great west road from London to Bath and Bristol crossed the vale between Devizes and Melksham. Rising rents, when land

[1] Treading kept the soil compact, and prevented the grass growing coarse and sour.

[2] See, in addition to Davis's account, W. Marshall, 'The rural economy of the southern counties' (1798), II, 331–45.

[3] 'The rural economy of the west of England,' 2nd ed., 1805, I, 3. What Marshall writes here on "natural" and "agricultural" districts has a distinct relevance to regional geography as it is conceived today. See also on the dairying of north Wiltshire his 'Rural economy of Gloucester etc.,' 2nd ed., 1796, II, 140–86.

was enclosed for, or converted to, pasture, testified to the appropriate use of this Oxford Clay land, "naturally wet and heavy, (and) apt to run quickly to grass." Fields were alternately fed to the cattle or mown for hay; cattle were stall-fed in winter, owing to the wetness of the ground; and care was taken to spread the dung over the pastures. The reputation of "North Wiltshire cheese," formerly known as "Gloucester cheese," since the technique of its making was introduced from the Vale of Gloucester dairies, was firmly established in the eighteenth century, and much was sent to London. So also north Wiltshire sent to London and Bath "winter veal": bull calves were better value as veal than as stock, and cattle could always be bought from Midland graziers. Some sheep also, for folding and for meat, were reared, and it is of interest that the practice of early slaughtering, to produce young, tender meat, was already established by the beginning of the nineteenth century.[1]

Despite the extent of chalk down and the emphasis on sheep farming, arable land covered at least one-third of south Wiltshire. Davis noted with concern "the rage there has been of late years for ploughing up sheep-downs," a comment similarly made by Defoe in the 1720's. The danger was that in curtailing the number of sheep, Wiltshire farmers were limiting the possibilities of arable farming. The dung of the sheep-fold, the chief purpose for which sheep were kept, was indispensable, then as now, in maintaining the productivity of the cultivated lands; moreover, wherever they went, and they ranged widely, sheep helped to fertilize the soil. The arable lands in south Wiltshire were distinguished as the "white lands" and the "flinty loam" areas, the former being best adapted and applied to wheat, the latter to barley. They were distributed in long belts, flanking the broad valleys which converge on the Avon near Salisbury. Even the "red" and "black" lands on the higher parts of the downs were in some places "burn-broken" for cultivation: the latter did not repay conversion to tillage, but the red land, which was improvable by chalking, was, if deep enough, worth breaking up for crops. About one-half of the parishes of south Wiltshire retained still, in 1794, unenclosed common fields: even so, although improvable, farming in south Wiltshire represented an effective use of the local possibilities. Parishes included arable land, down, and often meadow, much or all of which was used in common, and, thanks above all to their flocks of sheep, all types of land were exploited with profit. Warminster and Salisbury were the chief corn markets of south Wiltshire: the former supplied Somerset towns with wheat and barley, which their own county did not produce in sufficient quantities.

In north Wiltshire, also, cultivation covered a full third of the area. There were three main tracts. In the Greensand Vale of Pewsey sandy loam soils provided a good basis for arable farming which then, in contrast with to-day, characterized it. It was significant of the quality of these soils that periodical fallowing, which was the common practice in the chalk country, was not necessary, and clover, ray grass, turnips or potatoes were grown in lieu of

[1] In 1813 it is noted that sheep were killed before they reached two years of age, whereas "some years ago" they were not thought eatable until between four and six years old. This change was due partly to improved feeding and partly to changes in taste. See T. Davis, 'General view . . . of Wiltshire' (1813 ed.), p. 207.

fallowing. (The growth of fodder crops made possible the wintering of sheep from downland farms.) In the Vale, as also in the sandy tract below the down, from Devizes to Warminster, "esculent vegetables"—cabbages, peas, beans, carrots, turnips, and "vast quantities of potatoes"—were produced in market gardens for neighbouring and Somerset towns. The second arable district bordered the valleys and the escarpment of the Marlborough Downs. The third occupied the extreme north-western, or "Cotswold part," of the county: in this district stood "deep, cold lands over the bastard limestone rock" (the Great Oolite).

Finally, how much of Wiltshire could be classified as "waste" and woodland? Defining waste as "land in a state of nature, capable of cultivation, but of very little value in its present condition," Davis scouted the notion, then commonly held, that the Wiltshire Downs, and Salisbury Plain in particular, were waste land. Apart from pastures and arable fields, only relatively small patches of heath or woodland were to be found on the downlands. Similarly, although much common pasture survived in many parts of the county, especially in the south, and although its utility could have been increased by enclosure and better drainage, it was emphatically not waste land. In respect of woodlands, producing coppice or timber, the county was moderately well off. The use for fuel of "pit-coal" from Somerset and Newcastle had caused some neglect of the woods, which suffered, too, from grazing animals, and the "bleak naked hills," especially in the central parts of the county, were short of wood fuel. On the other hand, Davis estimated—rather generously—that the produce of the county was fully equal to its consumption, and reported the "amazing spirit of planting" which inspired the big landowners. This planting was chiefly for ornamental purposes, and included the Scots fir and larch—then fashionable—as well as oak, ash, and elm, the "natural timber" of the county. Certainly Davis's map shows many areas of woods, placed for the most part towards the borders of the county: the largest tracts were Cranbourn Chase, on the high down, and a portion of New Forest, both situated in the extreme south. Marshall, too, noted plots of woodland on the cool clays between Warminster and Shaftesbury.

Somerset

In the third edition of his report on the agriculture of Somerset (1798) John Billingsley estimated the acreage of land devoted to different purposes thus, in a total area of 1 million:

	Acres
Meadow and Pasture Land Enclosed	584,500
Arable and Convertible Land Enclosed	260,000
Common Fields (*i.e.* open arable fields)	20,000
Marsh and Fen-land Unenclosed	30,000
Uncultivated Wastes	65,000
Woods and Plantations	20,000
Public and Private Roads	15,000
Rivers, Lakes, Ponds, etc.	2,500
Towns and Villages	3,000

The accuracy of these figures in detail is doubtless questionable, the more so

since Billingsley did not undertake a specific survey. On the other hand, he was well acquainted with local conditions; he received reports from many farmers in the county; and further, the independent account of William

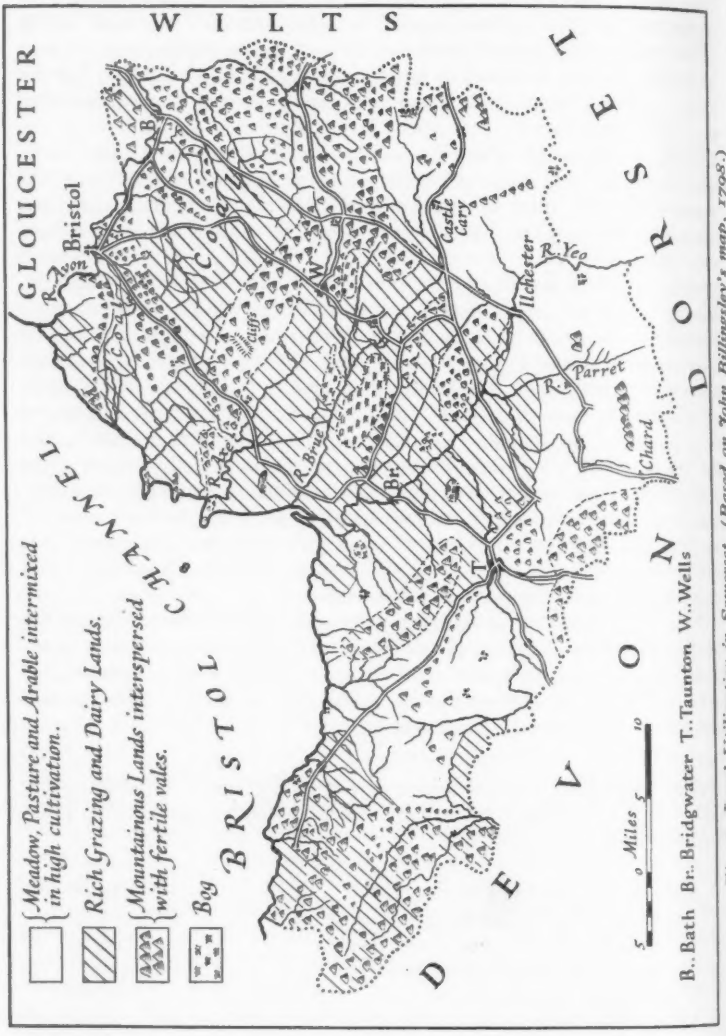


Fig. 3. Land Utilization in Somerset. (Based on John Billingsley's map, 1798.)

Marshall,[1] based on many visits between 1791 and 1804, does not challenge his general picture, which may be accepted as broadly, if somewhat generously, true. The figures suggest how almost the whole of this large county

[1] 'The rural economy of the west of England,' 2nd ed., 1805, vol. II.

had become enclosed and adapted to pasture and cultivation—especially to the former. In contrast, only a very small proportion of the county consisted of unenclosed marsh, woodland, and waste.

During his visit in 1804 William Marshall wrote [1]: "How rich in land is Somersetshire! comprising a far greater proportion of highly productive, and a less proportion of unproductive, surface, than any county in the Kingdom." The broad regional division of the county which he made may well serve in this brief review of the uses of the land. He distinguished, very reasonably, the following regions: the vale lands of north Somerset, together with marsh and valley lands towards the coast; the Mendip Hills, and other limestone heights in north Somerset; the "Sea Marshes," between the Axe and Parrett estuaries; the Valley of Glastonbury (the upper Brue); the Vale of Bridgwater; the Vale of Taunton, and other valuable lands in western Somerset; the Vale of Ilchester; the limestone range (Great Oolite formation), which girdled this vale to the south and east; and finally, in western Somerset, the broad high mass of Exmoor, and the Dulverton-Brendon, Quantock, and Blackdown hills.

In broad outline the uses of the land in Somerset, about the year 1800, stand out clearly in the two independent accounts of Billingsley and Marshall, and are illustrated in the map which accompanies the second and third editions of Billingsley's report in 1797 and 1798 (see Fig. 3). Marshall's account is the more valuable: he had a keen eye for regional differentiation. "To the north of the Mendips," he wrote,[2] "the Dairy is evidently a prominent, if not the principal, object of its husbandry." Thus the road from Bath to Axbridge, via the "rich, red and extensive Vale of Chew," passed through enclosed lands on the Lower Lias, Coal Measures and Red Marl formations, which were devoted alike chiefly to dairy farming, both on the hills and in the valleys. In the different parts of north Somerset the grass lands were turned to different purposes in some accord with the nature and position of the land: thus on the marshes towards the sea, grazing; in the vicinity of Bristol and Bath, milk production and haymaking. On the other hand, Broadfield Down, with good deep soils overlying the Carboniferous Limestone, was thought worth ploughing, although it remained a rough common of fern and furze, supporting some small-horned sheep. In contrast, on the Mendips, where deep, loamy soils covered the limestone rock, enclosure, associated with cultivation and sheep-folding, had made marked progress, for instance, at Charterhouse and in the lower south-eastern part of the hills Billingsley reckoned [3] that rather more than half of the Mendips was enclosed by 1794, and Marshall noted [4] fields where the Wells–Bath road crossed, and on the north-west face and summit, as viewed from Wrington. Where the plateau remained open, it was clad with grass, fern and brushwood, which afforded summer pasturage for sheep, whilst on its steep sides patches of coppice were found.

Fig. 3. Land Utilisation in Somerset. (Based on John Billingsley's map, 1798.)

[1] *Ibid.*, II, 359–60.

[2] *Ibid.*, II, 369.

[3] *Op. cit.*, p. 76. Billingsley gives here a table of the enclosed and unenclosed acreages in Mendip parishes.

[4] *Op. cit.*, II, 360–2 and 377–8.

At the southern base of the Mendips, between Cheddar and Wells, the narrow, well-settled strip of Red Marls was cut up into pastures (for dairying), arable fields and orchards. Beyond this, towards Polden Hill, there stretched, except for islands of hills, "a boundless extent of rich marsh lands." The "Sea Marshes," so-called, lying between Axbridge and Bridgwater, were an alluvial flat, covered by a retentive "fine close silt" and divided by "water fences" or drains into well-sized enclosures within which were fed "barren cows and sheep." There were also some fields, growing wheat, potatoes and hemp, and a few orchards; "Bridgwater cheese" was the chief local product; and the marshes yielded, too, turf or peat, the common fuel in this region. Farther east, the marshes of the Brue and Axe, separated by the wooded Wedmore Hill, had also been long divided and to some extent drained. Billingsley's plan [1] however shows that new drainage works were necessary and under consideration. To the south, beyond the cultivated Polden ridge, King's and West Sedgemoors, which lay within Marshall's Vale of Bridgwater, were reclaimed by improved methods only in the 1790's.[2] They remained however in a commonable state, and it is clear that their reclamation was less successful than Billingsley implied, since Marshall wrote,[3] in 1804, "when wholly appropriated (*i.e.* enclosed), and sufficiently freed from surface waters, (they) will be one of the most valuable Districts, of equal extent, in the whole Island." Further, some large tracts, which are shown on Billingsley's map as "turf bogs" (peaty swamps), still awaited reclamation. So also, to the north-west of the Mendips, some 3000 acres of marsh by the Yeo river were subject to continual inundation.

Towards the south, the Somerset levels were limited by a range of low limestone hills (the Lower Lias outcrop), which extended from the Vale of Taunton to Trowbridge in Wiltshire. This was undulating country, broken by many river valleys and their bordering areas of marsh. Except between Langport and Somerton, this region was entirely enclosed,[4] but the near-by marshes remained commons. Between Taunton and East Lydford (on the Brue), the land was used chiefly for arable crops, but also for orchards and sheep. In contrast, on the cold soils of the Valley of Glastonbury no arable fields were found: cattle rearing and dairying (for cheese), together with the rearing of sheep and pigs, were the main objectives of farming. In fact, eastwards of Glastonbury as far as Trowbridge, Marshall noted[5] "an extent of grassland Country, which is rarely met with, especially where the surface is greatly diversified."

Still farther south, an elongated tract, widest between Langport and Yeovil, extended north-east to south-west from Castle Cary to Chard: a hill-rimmed and undulating vale, this region was intersected by many rivers (*e.g.* the Yeo, Parrett, Isle and Cary) and by stretches of alluvial marsh. Marshall

[1] But if they were "firm dry *Marsh Lands*" and in no sense fens, when Marshall saw them in the autumn of 1791 and 1794, the Sedgemoors, after a spell of heavy rains, were under water in October, 1799. Barley was then being harvested from boats! They were also liable to inundation during spring tides. Marshall, *op. cit.*, II, 271.

[2] *Op. cit.*, p. 169.

[3] *Op. cit.*, II, 384.

[4] Marshall, *op. cit.*, II, 110.

[5] *Ibid.*, II, 112.

called this region the Vale of Ilchester, and it stands out on Billingsley's map as "meadow, pasture, and arable intermixt in high cultivation." Around the hilly margin of this vale stood many market towns, such as Yeovil, Ilminster, Langport and Castle Cary. The vale itself was floored for the most part with good clayey soils overlying limestone, and these provided an excellent basis for mixed arable farming. Although the Roman Fosse Way from Bath to Exeter bisected the Vale of Ilchester, inadequate roads long retarded its full exploitation: in the last decades of the eighteenth century however improvements, thanks to turnpike trusts, were already having a good effect.[1] Finally, it may be worth noting that red Devon cattle intruded, as it were, into the vale, west of Ilchester.

In west Somerset, the Vale of Taunton, based on Red Marls, formed a region of conspicuous fertility, cut up into fields by "live," woody hedges. It stood higher than the marshes of the Vale of Bridgwater, to which it opened out in the east, and was enclosed by steeply rising country to the north, south, and west, by the Quantocks, the Blackdown Hills and the Dulverton-Brendon hills respectively. Deep rich sands—"carrot soils"—covered the northern part of the Vale; in the south were strong red loams. Grain, above all wheat, together with turnips, beans, and flax, were the chief products; there were many apple orchards, some pasture around the towns, and little wood, except in the hedgerows. A similar arable tract flanked the Quantocks on its eastern and western sides.

It is significant of the use made of the land in Somerset that, on Billingsley's figures, only about one-eighth of the county was classified as unenclosed marsh, woodland, and waste. This is the more striking since the county contained so many high areas and low alluvial flats. Few of the uplands were entirely waste: there were usually coppices on the slopes and rough pasture on the summits. Nor did they lack cultivated areas: Billingsley was careful to note that it was expedient, in exposed and elevated situations, to sow seed a fortnight earlier in autumn and a fortnight later in spring than was customary in the plains. The high plateaux, it should be added, were marginal lands for cultivation: a cool summer, as in 1792, spelt ruin for their crops. The increasing usefulness of the Mendips, thanks to improvements consequent on enclosure, has already been noted; nor was the high Forest of Exmoor, which occupied some 20,000 acres, entirely unproductive. Certainly it was bare of trees, almost uninhabited, very badly served by roads, and partially covered by swamps; even so, it "summered" 22,000 sheep and 400 horses.[2] Marshall believed that the Forest of Exmoor and the Brendon Hills formed "the most, and almost the only, unproductive, part of Somerset." The valleys of the much-dissected Quantock plateau were cultivated, and its summit bore, besides heath on the higher ground to the west, grass and "upland sedges," useful for grazing in summer. Similarly, the Blackdown Hills, of which only a part lay in Somerset, had cultivated valleys, and they pastured young cattle

[1] Unfortunately for south Somerset it was avoided by the great west road from London to Exeter by way of Andover, Dorchester and Honiton, although it lay on the direct line. Marshall (*op. cit.*, II, 331–8) discussed a scheme, which was being considered *c.* 1800, for a road to Exeter by way of Andover, Ilchester and Honiton. This would have improved the marketing possibilities of the Vale of Ilchester.

[2] Billingsley, *op. cit.*, p. 288.

and sheep on the herbage of their thin black soils. The Lansdowne, near Bath, also afforded good sheep pasture, and its scanty soil was certainly not worth cultivation. Thus, on the uplands, land entirely waste was not so very considerable. In the lowlands, too, reclamation of the remaining fens and peat bogs was fast reducing this kind of waste. Some 9000 acres of peat bog, useless for pasture but useful for fuel supplies, formed a desolate waterlogged tract on both sides of the river Brue (see Fig. 3), but plans were being considered for their improvement.[1]

Finally, it may be added that Billingsley rightly regarded Somerset's specialization on grass farming as an adaptation to its climate: the "watery vapours," common especially in the west, were unfavourable to the ripening of corn. Actually, since the county contained a considerable industrial population, its own corn supplies were insufficient, and much was brought in from Wiltshire and Dorset markets. On the other hand, Somerset produced a surplus of fat oxen, sheep, and hogs, together with cyder, cheese, and butter, much of which was sent to London, Bristol, and elsewhere. Its coal-pits, too (see Fig. 3), were producing about 2500 tons weekly, and for the transport of this marketable commodity canals were being cut.

Enough has been given above to indicate how far, in three selected regions, the use of the land was adapted to its physical characteristics and to the economic circumstances of the time. The present-day uses of the land, and all that they must show of permanence and of change as compared with those obtaining at the end of the eighteenth century, cannot be examined here. In conclusion it need hardly be urged that, if the utilization of the land is regarded, as it should be regarded by geographers, as a variable function of man's efforts to adapt his environment, it is helpful, in order fully to understand the present conditions, to consider them in relation to those of earlier times. So, too, it may be well worth while for those who have policies for agricultural improvement in this country to examine the uses to which, under different economic conditions, the land was put, for it is the self-same land, with the same varieties of climate and physical texture, which they seek to improve.

[1] See the plan in Billingsley, *op. cit.*, p. 169.

REVIEWS

EUROPE

A GEOGRAPHY OF EUROPE. By H. ALNWICK. (Harrap's New Geographical Series. General Editor: R. N. RUDMOSE BROWN.) *London: George G. Harrap & Co.*, 1935. $7\frac{1}{2} \times 5$ *inches;* 416 *pages; illustrations and maps.* 3*s* 6*d*

This book, dealing mainly with the Human Geography of Europe (excluding the British Isles), is intended for pupils preparing for the Matriculation and General School examinations. It is an interesting and readable work, and the author follows the excellent modern mode of providing an abundance of well-chosen photographs, while his diagrams are both numerous and ingenious. The main defect of the book, namely, its small size, is one which is unfortunately shared by many textbooks for school use. It is obvious that a small volume such as this cannot do justice to a subject of such complexity as the continent of Europe, but while school authorities insist on an expensive binding it is obviously impossible to publish a large book at a low price. Only by adopting the continental practice of binding school books in light cardboard is it possible to produce a book of adequate length at a reasonable figure. As it is, the work suffers from a certain lopsidedness, and though one would not wish for less on the human and sociological aspects, yet there is certainly not enough space devoted to considerations of relief, structure, climate, soils, etc. Incidentally, physical geography does not seem to be the author's strong point. For instance, the southern edge of the Baltic Shield is not marked by a chain of lakes across Sweden as he alleges, and his statement that the Russian platform is denuded from a vast mountain stump is distinctly misleading. The book should prove a stimulating supplement to the more formal textbook, but it is not sufficiently comprehensive for use as a sole book of reference. M. R. M.

NO LONGER POLES APART. By HENRY BAERLEIN. *London: Longmans, Green* (1936). $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* x+340 *pages; illustrations and sketch-map on end pages.* 15*s*

In the choice of a title, the strain of facetiousness which is in Mr. Baerlein won its worst and almost its last victory. Thereafter, in company with the soda-water manufacturer and Mr. Baerlein himself, the reader may wander round Poland, untroubled by bright remarks or the conventional sayings of travellers. It is a sentimental journey, in which history and politics, save for one or two stories at which even a dictator might smile, are eschewed. Between Wilno and Krakow, by way of the Polesian marshes, Mr. Baerlein and Teofil follow their fancy; and a style which is reminiscent of Sterne entitles an author to digress, to consider the ways of the Caraïms, the Hutzuls, and the Goorals, and even to include a fairy tale from old Japan. J. P. H. M.

SCRAMBLES AMONGST THE ALPS. By EDWARD WHYMPER. Sixth Edition. With additional illustrations and material from the author's unpublished diaries. Revised and edited by H. E. G. TYNDALE. *London: John Murray*, 1936. $8\frac{1}{2} \times 6$ *inches;* xxii+414 *pages; illustrations and maps.* 10*s* 6*d*

Edward Whymper was born in 1840. By trade he was a draughtsman on wood, and he inherited from his father considerable skill as an artist in water-colours. Hence it came that, when only twenty years of age, he was invited by William Longman, publisher and a prominent member of the Alpine Club, to make drawings of the mountains of Dauphiné for the second series of 'Peaks, Passes

and Glaciers.' On his way to Dauphiné he visited Saas and Zormatt, and made a tour through the Oberland and Savoy. His attempt on Mont Pelvoux failed; but in the following year he tried again and succeeded, and then made his first attempt on the Matterhorn. In 1862, 1863, 1864, and 1865 he made six more unsuccessful attacks on the latter mountain, and, at last, on 14 July 1865, he reached the summit, though four of his companions perished on the descent. This accident put an end to his serious mountaineering in the Alps, though he frequently visited them in later years and made expeditions among the Andes, in Greenland, and in the Canadian Rocky Mountains.

This book, originally published in 1871, is the story of the marvellous six years—the golden age of mountaineering. When it first appeared, Leslie Stephen described it as "the congenial record of the most determined, the most systematic, and, on the whole, the best-planned series of assaults that were made upon the High Alps during the period"; and of its author he says that "he deserves the special credit of having carried to the highest point that spirit which, in an inferior degree, distinguished all the mountaineers of the later epoch from their predecessors." The tragedy of 1865 not only ended Whymper's career as a pioneer in the Alps, but also checked the development of British mountaineering generally. It came to its full strength again with the rise of Mummery and the guideless exploits of the Pilkingtons and Fred Gardiner. Dent in his siege of the Dru displayed as fine a determination as Whymper on the Matterhorn. And among these men, and others who must be nameless, there were climbers as bold in conception, as tireless in execution, with possibly greater knowledge and more advanced technical skill. But Whymper's book still stands alone among the classics of English Alpine exploration. It has an epic quality. Stephen thought that there was an "absence of good set eloquence as to views and panoramas." But it is written in strong, firm English, revealing the determined character of its author, a man with a keen sense of natural beauty, capable of joy, possessed of wit and humour, but, perhaps, over eager for success, ruthless, impatient of sloth or cowardice. Though composed in great part from old papers and old diaries, it moves continuously to the predestined disaster, which seems to round it into a perfect whole.

A great part of the fascination of the first edition and of the many subsequent reprints lay in the beauty of the illustrations, the product of Whymper's own vision and skill as draughtsman and engraver. They here appear, again, accompanied by photographs well selected and admirably reproduced. Mr. Tyndale has added passages, hitherto unpublished, from the diaries, and a certain amount of additional matter on the details of the accident of 1865 and on the later history of the Matterhorn. The result is a volume which every mountaineer will desire to possess, however many editions of Scrambles already fill his shelves. C. S.

ASIA

INDIA'S MINERAL WEALTH: A guide to the occurrences and economics of the useful minerals of the Indian Empire. By J. COGGIN BROWN. *London: Oxford University Press*, 1936. 9×5½ *inches;* x+336 *pages; illustrations and maps.* 15*s*

Popular tradition regards India as the land of gold and diamonds, but Indian production of both has sunk to insignificance. Since the beginning of this century however there has been an enormous increase in the output of more prosaic minerals. Coal, mainly from the Lower Gondwana beds of the Peninsula, has increased fourfold; petroleum, mainly from the Lower Irrawaddy, seven or eightfold; mica tenfold. The smelting of iron ore, and the production of lead

and tin ore, which had scarcely started before 1910, have since increased about ninefold. The increase of silver production since 1915 is even more rapid. Most of these minerals have suffered a drop since 1932: tin is an exception. Other minerals which were once valuable exports have greatly shrunk in volume since 1918—notably saltpetre and monazite.

Such are a few of the prominent features of Indian mineral development of the last thirty-six years that can be gathered from this very detailed and exhaustive survey. Every kind of mineral—metallic ores, fuels, gems, building-stones, brick-earths, and pottery clays, salts, mica—are fully treated: their geographical and geological distribution, methods of exploitation, destination and uses are explained, as well as the statistics of production. Dr. Coggin Brown is to be congratulated on the successful end to a very heavy task.

It is a geographical anomaly, whatever its administrative justification, that the Indian Empire, though it includes Burma, does not include Ceylon. There is no geological map of Ceylon. Members of the Geological Survey of India cannot visit Ceylon except on leave, when they naturally prefer to visit Europe. If the minerals of Ceylon were included in this survey, though the book would not be appreciably enlarged, some parts of it might be considerably altered.

A. M. D.

AFRICA

JOURNEY WITHOUT MAPS. By GRAHAM GREENE. *London: William Heinemann*, 1936. 9×5½ *inches;* x+296 *pages; illustrations and sketch-map.* 15*s*

Mr. Greene, unmoved by any ambition to add to the sum of geographical knowledge, appears to have gone to Liberia because it is a little-known and presumably a difficult country to travel through. But there was also a further motive: he records that "when one sees to what unhappiness, to what peril of extinction centuries of cerebration have brought us, one sometimes has a curiosity to discover if one can from what we have come, to recall at which point we went astray." This curiosity was certainly satisfied: almost on the last page of his book he writes, "I have no yearning for a mindless sensuality, even if it were to be found there: it is only that when one has appreciated such a beginning, its terrors as well as its placidity, the power as well as the gentleness, the pity for what we have done with ourselves is driven more forcibly home." Though he is thus largely concerned to set down his own sentiments in the midst of so strange an environment, he does not adopt the device of minimizing the difficulties encountered on what was undoubtedly a considerable achievement for an inexperienced traveller, and the reader will gather from his book a vivid impression of what Liberia is.

He entered the north of Liberia from Sierra Leone, thus striking the primitive country first, and so unbiased by impressions of the coast and its veneer of civilization. Travelling, sometimes in French Guinea, as far as a tributary of the Cess River, he then made for the coast at Grand Bassa. The earlier portion of his route coincided fairly closely with that of Sir Alfred Sharpe, described in this *Journal* for April 1920. He pays great tribute to the honesty and courtesy of his carriers, who stood by him at many critical moments. Towards the end of his journey he encountered President Barclay, the first president to tour the interior, whom he pictures as "a black preaching progress to a sceptical white," and Colonel Elwood Davis, whose activities had lately been a matter of international concern. It is perhaps too easy to poke fun at the state of affairs on the coast, and Mr. Greene has wisely refrained.

G. R. C.

NORTH AMERICA

DIE RÄUMLICHE GLIEDERUNG DER LANDWIRTSCHAFT IM nördlichen Kalifornien. By GOTTFRIED PFEIFER. (Wiss. Veröffentl. Ges. Erdkunde Leipzig. Zehnter Band. Festschrift zum 75 jährigen Bestehen.) *Leipzig: Ferdinand Hirt & Sohn*, 1936. 10×7 *inches;* 310+16 *pages; illustrations and maps. M.*18

Although the author signs the preface as university lecturer at Bonn, his evident intimacy with the "Golden State" dates from a three years' apprenticeship served under Professor Sauer at Berkeley. The plan of this 300-page study is well thought out and results in an instructive analysis of the factors responsible for the details of present-day agricultural distribution.

After a brief prologue on previous (*i.e.* Indian and Hispano-Mexican) settlement up to the time of the Gold Rush, Pfeifer presents his material as two acts in a still unfinished drama. Selecting two "milestones" seventy years apart, he analyzes the factors on which their outstanding contrasts depend. Three-quarters of a century ago official statistics lacked the completeness of modern annual returns, so he chooses the decades 1850–1870 as the scene on which the curtain rises. Act II takes place in 1930 and shows the situation revealed by the census for that year and his own recent field observations.

The population of California had increased tenfold from 1848 to 1850. It doubled again in the next two years. The main concentrations were round San Francisco and in the Mother Lode area of the Sierra Nevada, proving that the increase in numbers was due primarily to those who followed in the steps of "the miner, the forty-niner"—the 1850 census shows 57,797 miners, 5400 traders, and only 2004 ranchers and farmers! Agriculturally speaking therefore the overwhelming majority were consumers, not producers.

By buying when land was cheap, one five-hundredth of the population soon owned half the available acreage, and despite the attempts of the Land Commissioners to settle the plethora of cases where squatters' rights, riparian claims and the like conflicted with the aims of powerful landowners, the man without influence often failed to secure title to his claim and could only go back east. It was against this background of unadjusted balance, social and economic, that the first act in the drama of agricultural development was played. The author describes the rapid increase in cereal production, the beginnings of the fruit and vegetable trade, the spread of dairy-farming and stock-raising, taking the story down to the year when the completion of the first trans-continental railway again radically altered the situation.

During the long interval between Acts I and II, several new factors have made their appearance on the stage. The Panama Canal now cuts sailing times in half, and perishable products avoid a double trip through tropical waters; war and its aftermath have recast the pattern of markets and trade routes; motor trucking over fast cement roads has become a standard means of collection and distribution, geared to a system of improved cross-country rail transportation and refrigerated storage. The labour problem had been a source of worry as long ago as 1883. We find the authorities of those days perplexed as to how to counteract the drift of young people off the farms to the cities. The employment instead of Mexican, Chinese, Japanese, and Philippino immigrant labour brought its own crop of miseries in tow. The problem of migrant farm labour to-day is only touched on in passing.

More than half the book is given to a discussion of the detail of present-day agriculture. The first section deals with the economic aspect of supply and demand—markets, labour, irrigation rights, and problems of distribution. The

second section takes up the physiographic factors which have controlled the great agricultural expansion. Then comes a discussion of specific types of farming and ranching in relation to the demand that has stimulated the growth of each. The concluding thirty pages gives a comparative survey of agricultural distribution. Good use is made of specially prepared maps not only of the main varieties of produce, but also of soil types, modes of irrigation, limits of cultivability, and the like. These are based on 1930 census data, but in many instances significant extrapolations in the text bring the statement down to 1934. The much-reduced crop-density maps (*e.g.* those grouped on p. 243) leave something to be desired, as the conventions used for percentage yields give a confusing visual impression. The sixteen pages of photographs placed together at the end of the volume are well chosen, but some of the best pictures suffer from over-reduction. A useful bibliography lists 330 publications grouped under fourteen major topics, the one on produce being further subdivided into eight types.

The author is at pains to emphasize a fact we sometimes forget, that the last act of the drama has still to be played. Radical changes are once again taking place and the full implication of some of the adjustments in progress to-day may only be appreciated in retrospect. G. B. B.

THE KINGDOM OF SAGUENAY. By MARIUS BARBEAU. *Toronto [and London]: The Macmillan Company*, 1936. $9\frac{1}{2} \times 6$ *inches;* 168 *pages; illustrations and sketch-map.* 12*s* 6*d*

Under this name Mr. Barbeau, who is well known for his work in Canadian folk lore, has collected a very interesting set of studies relating to Quebec. The best and longest is that on the Kingdom of Saguenay, which includes the results of Abel Lefranc's studies upon Cartier's relations with Rabelais. These he has set out in a most interesting manner. Why he should call the Pygmies Pigmeous instead of Pigmeons one cannot understand. He must know that a stroke over a vowel in early use meant that the letter *n* had to be added. Moreover the Descelliers map prints this word in full. Cartier sailed in 1541, not 1540.

The 'Wood Carvings for a Parish Church' is an excellent study and breaks completely new ground, as does also 'Père Raquette,' in which we get some interesting notes on many modern Canadian artists. 'The Blind Singer' shows Mr. Barbeau at work collecting old French songs, of which the Museum at Ottawa has a great store. The remaining studies border on the miraculous and are more in the nature of folk lore. Mr. Barbeau has done good service in publishing them and they add a romantic flavour to this part of Canada.

There are a few slips, due perhaps to translation. Even when the saint is a lady he uses indiscriminately St. and Ste. On p. 21 "latin" should have a capital, and *coureur-des-bois* should surely be *de-bois?* The illustrations add very greatly to the interest of this volume and have been done by leading Canadian artists. H. P. B.

AUSTRALASIA AND PACIFIC

THE ODYSSEY OF A DIGGER. By F. D. BURDETT. *London: Herbert Jenkins*, 1936. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 316 *pages; illustrations.* 15*s*

This is an edited version of the author's experiences as a miner in Australia, for which country he set sail in 1878 at the age of fourteen years.

Had the book appeared in the late 90's or the early part of the present century, and been written in the colloquial jargon of the early Australian mining days, it might, conceivably, have attracted a greater reading public than is likely to-day.

As it is, it is doubtful whether interest in Mr. Burdett's reminiscences would warrant reading three hundred odd pages which contain a sprinkling of interesting adventures "laced" together by a disproportionate number of very commonplace happenings. F.

POLAR REGIONS

ANTARCTIC DISCOVERY: The story of the Second Byrd Antarctic Expedition. By Rear-Admiral RICHARD EVELYN BYRD. *London: Putnam*, 1936. 9½×6 *inches;* xxii+422 *pages; illustrations and maps.* 18*s*

Rear-Admiral Byrd's first Antarctic expedition took place in 1928–30, its principal features being the leader's own flight to the South Pole, and a fine journey by dog sledge led by Laurence Gould to Amundsen's Queen Maud Range. These have already been described in 'Little America,' the book having taken its title from the expedition headquarters near the edge of the Ross Barrier in the Bay of Whales. 'Antarctic Discovery' deals with the second expedition, in 1933–35; the base was again at Little America, but the "boom city," as Byrd calls it, had to be expanded and re-dug to accommodate a wintering party of fifty-six. The main objective had now become exploration on a broad front eastward of the winter quarters, that is to say, to the region lying between the north coast of Marie Byrd Land and the Queen Maud Mountains; and the leader had at his disposal two ships, four aeroplanes, nine dog-teams, four tractors, and two light snow-mobiles: an outfit only paralleled for diversity and size by Byrd's own earlier expedition. Dog teams were represented, but reliance was placed mainly on machines; the expedition can fairly be described as essentially mechanized; and this book therefore must be of importance in showing how far mechanical means have justified themselves in the Antarctic.

Most readers would no doubt have predicted that, after the experience of the earlier expedition, work from the air would by now have swept all before it; but this is by no means the case. In some ways the air work falls short of the earlier flights, and a bigger share of the honours again goes without question to the dog teams. Byrd himself says: "Planes and tractors are superb instruments, but there is no getting away from dogs. The Eskimo husky still is, as he always has been, the one absolutely reliable means of polar advance." Two dog journeys stand out—a 77-day trip north-eastwards to Marie Byrd Land for survey and geology, in which 862 miles were covered; and a 1410-mile journey to the Queen Maud Range (to within 207 miles of the South Pole) lasting 88 days, the final 427 miles being covered in 16 days. These two journeys—the distances are apparently statute miles—are not only splendid performances in themselves, but they also provide the most important geographical results of the expedition. This should be stressed, as there is throughout the book a habit of confining the phrase "geographical discovery" to aeroplane flights into unmapped territory, and withholding it from slower and more accurate work on the ground.

That the aeroplanes did not contribute so much to the expedition results as the dog teams was partly due to weather, but more to the small number of opportunities which they had of landing at any distance from the Base. The tractors in turn suffered from limited range. Byrd sums up the weakness of aeroplanes as their dependence on weather, and of tractors as their inability to pass through crevassed country. This weakness in the tractors is made abundantly clear throughout the narrative, and much of the ground was quite impracticable to the machines, although it could be threaded without much

difficulty by dog teams. At the same time it must be emphasized that the work of the tractors was the reverse of negligible, and in the end they proved of immense value once their teething pains were over. In particular they bore the brunt of transporting about 400 tons of equipment from the ship to Little America, a distance never less than 7 miles over a varying amount of pack-ice and barrier. When not on crevassed ground and on a really firm surface the tractors' efficiency was remarkable; on a return trip from a depot journey to the south Harold June's tractor, for example, covered 120 miles in 16 hours; and another on a run back from the Rockefeller Mountains covered 160 miles in 28 hours. When sent south in the summer however the tractors failed to penetrate the crevassed line which runs across the Barrier in 81° S. This led to a change of programme, and they were ordered to turn east to penetrate Scott Land, where important soundings of the ice thickness were made. Tractor No. 3 alone lasted to the end on this trip, and just managed to get home under her own steam, having accomplished an 815-mile journey in 69 days.

Throughout the expedition the tractor drivers' problem was to beat the cold, and accordingly the machines seemed at their best on regular to-and-fro work from the Base. Down to 1 June 1934 the total tractor mileage was 11,500 miles—a figure which effectively answers the charge that the tractors were a failure. They are no doubt still unreliable compared with dog teams, but this should hardly be the case for very much longer, and newer models with greatly increased length will overcome all but the very biggest crevasses; in fact, Antarctic "landships" of immense size may soon become a reality rather than a dream.

The apparent failure of the tractors to do all that was wanted of them leaves little feeling of disappointment. This is not however the case with the aeroplanes. As regards the flights there is a definite impression of failure, though perhaps only because more startling and effective results had been expected. The reason for non-success was largely the avoidance of landings except fairly near the base, and it seems evident that the aeroplane in the Antarctic has not as yet been developed for reliable use either for air mapping with ground control or as a supply service for parties working at a distance from the expedition base.

Admiral Byrd's book therefore is of most value for the technical lessons which may be learnt from it, but it is not everybody's book, and it suffers from a lack of adequate maps. The landing operations for example monopolize the first half of the narrative, but there is no diagram or map to illustrate these lengthy events, and the reader must refer to 'Little America' for a sketch-map of the neighbourhood of the winter quarters in the Bay of Whales. The earlier book however suffers from the same deficiency in charts and maps. In 'Antarctic Discovery' the only maps are a small sketch of the ship routes and an operation map on the end papers crinkled at the hinge-line and on a scale no larger than 1 in 6,000,000—a poor accompaniment to an excellent appendix on maps and survey. In 'Little America' the general map is on an even smaller scale. A comparison of these two general maps also shows the danger of accepting discoveries made from the air alone, as the north coast of Marie Byrd Land is now after proper survey placed 100 miles south of its position on the earlier map based on air reconnaissance. This and the unexpected corrections which have recently been made to Wilkins' outline of South Grahamland are no doubt extreme cases; but in the present instance they at any rate suggest caution in accepting the view given in the book that the problems of the country east of the Ross Barrier are finally disposed of as a result of the expedition flights. J. M. W.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

NOTES ON PHENOMENA OF A GEOPHYSICAL NATURE. By G. F. TYDEMAN. *Leiden: E. J. Brill*, 1936. 9×6 *inches;* xii+144 *pages; diagrams.* 2.50 *guilders*

This essay is an attempt to establish the thesis that our present theory of tides is seriously incomplete owing to the fact that it does not consider certain forces which are held by the author to be of major importance as tide producers. These forces—the "Tangential Forces"—are those components of the attractive forces exerted by sun or moon upon the individual particles of the Earth, which are tangential to the momentary directions of motion of these individual particles relative to the attracting body. The weight of the contention will be realized from the statement that the calculated magnitude of these forces would show them to be many times larger than the accepted tide-producing forces, and would reverse the importance of sun and moon as regards their respective shares in tide generation. The theory thus encounters a considerable difficulty in explaining the evident preponderance of the moon in the production of the actual oceanic tides, and the fact that complicated tides are successfully predicted on the generally accepted theory, using the theory to determine the form of the terms, whose coefficients are established by analysis of the observations.

The author passes on to consider the solid Earth, which his deductions lead him to suppose much less rigid than is generally held to be the case. With this supposition in mind, he seeks confirmation of his ideas by attempting to employ them in an explanation of the phenomena of orogenesis and the geographical distribution of past glaciations. Geophysicists will not favour the disregard of some of their better-established conclusions, and geologists will hardly know what to do with opportunities for apparently wholesale and inevitable diastrophism which are offered them. D. L.

HANDBUCH DER KLIMATOLOGIE. Band I, Teil B: Die klimatologischen Elemente und ihre Abhängigkeit von terrestrischen Einflüssen. By V. CONRAD. xii+556 *pages; illustrations, sketch-maps and diagrams.* Band I, Teil C: Das geographische System der Klimate. By W. KÖPPEN. 44 *pages; sketch-maps and diagrams.* Band I: Titel, Vorwort, Inhalt, alphabetisches Sachregister. x+12 *pages* (*at end of volume*). *Berlin: Borntraeger*, 1936. 10½×7 *inches. M.*54

HANDBUCH DER KLIMATOLOGIE. Edited by W. KÖPPEN and R. GEIGER. Band II, Teil J: The climates of North America. By [the late] ROBERT DE C. WARD, CHARLES F. BROOKS, and A. J. CONNOR. *Berlin: Borntraeger*, 1936. 10½×7 *inches.* [First part: Mexico, United States, Alaska.] x+326 *pages; maps and diagrams. M.*45 (*Subscription Price M.*36)

The appearance of two more volumes of the magnificent handbook of climatology which is being issued under the editorship of Köppen and Geiger will be welcome to students. Of the two new volumes, the first contains a discussion of the climatological elements and their dependence on terrestrial influences by R. Conrad, and a brief account by Köppen of the principles underlying his classification of climates. The last is a useful account of the subject, and can be recommended as an excellent introduction to Köppen's writings. In it he gives an outline of each of the eleven main types into which he divides the climates of the globe. Not the least helpful item in this account is the set of diagrams of the annual distribution of temperature and wind in each of these types, shown in Fig. 4. We should have liked to see this diagram on a larger scale, since diagrams are often more illuminating than text.

In the larger part of the first volume referred to, Teil B, Conrad takes a wide view of the province of climatology. Along with copious data of the distribution of the climatic elements over the surface of the Earth, of their distribution in the vertical, and of their diurnal and annual variation, we find considerable discussion of the physical basis of the inter-relation of the elements and of the effect of location, height, and aspect of the places of observation.

Conrad begins with a section on the radiation coming into the Earth's atmosphere from the sun, and the radiation from the surface of the Earth and from the atmosphere. Observations of total radiation and of ultra-violet radiation reaching the Earth's surface at different heights above sea-level in different latitudes are given in tables, and the section ends with a discussion of the balance between incoming and outgoing radiation along the lines of Simpson's memoirs. The next section deals with the constitution and impurities of the atmosphere, while the third is devoted to the observation of temperature, its distribution over the globe and in the vertical, and its daily and yearly variations. Here we find an attempt to discuss the best method of obtaining a fair representation of the average temperature of twenty-four hours from observations made at certain standard times. The average and extreme values of the lapse-rate of temperature are also shown in tabular form.

The section dealing with wind and air-flow treats of the general circulation of the winds of the globe, the wind systems in the depression of middle latitudes as represented by the Norwegian and Austrian schools, and special winds such as land and sea breezes, hill and valley winds, and other local winds which have earned special names on account of some unpleasant characteristic.

The longest section is devoted to the discussion of the hydrometeors, and in this section we find water vapour in the Earth's atmosphere treated in all its aspects. Conrad not only discusses the measurement of temperatures of thermometers with wet and dry bulbs, but also deals with more complicated functions of temperature and humidity, such as equivalent temperature. The theories of evaporation are briefly discussed, though the difficulty of applying laboratory experiments to problems of evaporation in the free air from large sheets of water does not appear to the reviewer to be sufficiently stressed. The variation of vapour pressure with place and with time of day or year is illustrated by examples. The parts which are devoted to precipitation are very well selected, the effects of contour, and of location generally, being taken into account. A welcome feature is the inclusion of examples of well-marked diurnal variation of rainfall, not usually to be found in textbooks of any kind.

This is a book to have near for reference rather than one to be read through. It contains a vast amount of information both as to methods and results of observation, as well as of methods of representation of observations. It contains also a very large number of references to original papers, and though here and there some surprising omissions were noted, the bibliography is on the whole very complete.

The volume on the climate of North America completes the discussion of the climates of America, except for Canada, which will be the subject of the next volume to appear. The editors of the volume were the late Professor R. de Courcy Ward and Professor C. F. Brooks, but many others have also contributed to its preparation. It is in three sections, dealing respectively with Mexico, United States, and Alaska, with an introductory short section by R. de C. Ward on the physical features of North America and their action on the climates of the continent. In each of the sections, temperature, pressure and winds, rainfall, humidity, sunshine, cloudiness and fog, thunderstorms, and other special features of the weather, are discussed in turn, and where maps

are given, they cover the whole of North America, including Canada. The climatic divisions of the continent are indicated, a brief discussion of the division of Mexico and the United States into Köppen's climatic provinces being given by Köppen himself. The chapters on Climate and Vegetation, and on Climate and Population, of Mexico, and the chapters on Climate and Crops, and on Climate and Health, of the United States, are among the most interesting parts of the volume. Each section ends with very full tables of the meteorological observations available. These alone would make this a most useful volume. The tables of references to original papers are lengthy, and the whole volume gives an impression of careful and thorough work. The many collaborators who helped to make it are to be congratulated on the pleasing result of their joint efforts. D. B.

CARTOGRAPHY

MAP MAKING. By FRANK DEBENHAM. *London: Blackie & Son*, 1936. $7\frac{1}{2} \times 5$ *inches;* vi+240 *pages; illustrations.* 5*s*

This book is in the same series as the recently published 'A Key to Maps,' by Brigadier H. S. L. Winterbotham, and is in a sense the preceding volume, for it deals with the simpler processes of map-making as they may be carried out by the amateur. As the author says in his preface, he has tried to remove some of the awe and mystery in which surveying has been shrouded. He must be a singularly dull and unimaginative reader who does not understand and burn to carry out the easy methods of map-making described in this very attractive book.

Starting with a story well known in Cambridge circles, Professor Debenham explains clearly the main principles of survey in an introductory chapter, and, after dealing with the problem of scale, goes on to detail the various rough methods of measuring distances and angles. In chapters VIII and IX he describes plane-tabling very fully and makes it sound extremely fascinating. There is a chapter on the use of photographs in surveying; and one on instruments and their cost, describing a few home-made ones which professional surveyors may find a little shocking. This is not however a book for the professional, who will find little new in it, nor is it one for the explorer or traveller, however rough or rapid his surveys may be. It is intended for the scientist whose work is in any way geographical: the geologist, botanist, ecologist, or even the human geographer, who wishes to plot his own detail on existing maps or to make maps of his own. With this in view it is easy to understand why only large-scale surveys—greater than 1/100,000—are dealt with, for after that, as the author says, the work becomes harder and more complicated. With this limit he is able, in the comparatively small compass of the book, to deal with his subject in great detail, and the amateur surveyor will find much information that he would only learn otherwise by bitter experience.

There are one or two criticisms one may fairly make. In chapter II there is an inadequate description of the usual arrangement of a scale, with a short length of the smallest graduations numbered away from the zero in the opposite direction to the main scale. This is not made clear, and a diagram would have been worth while. More serious is the omission of any mention of the diagonal scale. The use of a compass for measuring angles as opposed to bearings is not sufficiently brought out; by this means local attraction may be eliminated. Nor perhaps is sufficient mention made of the type of compass traverse in which the bearing of a line of travel is measured rather than that of a point ahead, as, for example, in a boat.

In the chapters on plane-tabling the following hints might have been included: The use of hexagonal pencils is not sufficiently stressed; round ones will never stay on the table in any wind. Also the indiarubber can best be disposed by attaching it to the alidade by a length of string. Rubbers bounce far if dropped off a plane-table and are easily lost in rocky ground. The use of tracing paper for resection (p. 152) is perhaps too easily dismissed: it is common in the Ordnance Survey.

These however are small criticisms, and there is no doubt that this book, which has been long awaited, satisfies a very real need. From it all those who have wished to make rough maps, for fun, or to aid their researches, may now learn easily and quickly how to do so. It is very pleasantly and clearly written, and illustrated by nearly a hundred attractive drawings in the text, many of them by the author's own hand. There are two short appendices on lettering and conventional signs, a traverse table and table of natural tangents, and an index. This book should have a wide sale among geographers and all who are interested in maps. J. W. W.

ECONOMIC AND HISTORICAL GEOGRAPHY

SCOTT OF THE SHAN HILLS: Orders and impressions. Edited by G. E Mitton (Lady Scott). *London: John Murray*, 1936. 9×5½ *inches;* xii+348 *pages; illustrations.* 15*s*

This book is the biography of Sir George Scott, one of Burma's greatest servants, told by his wife in extracts from his reports and diaries and letters. But it is more than this: it is a stirring account, written at the time by one of the participators, of the pacification and growth of the Burmese Shan States, and will hence be welcomed not only by all who know and love Burma but by those who are interested in the history of our Empire in India.

In 1886 James George Scott was appointed to the Burma Commission. He was ordered first to Meiktila. Meiktila, now in the centre of Burma, was then a frontier post; " there were not only no books in the place, but there was not even paper, pens, or ink." Scott had great difficulty in obtaining the necessary works for passing his examinations.

After six months at Meiktila, Scott was appointed Assistant Commissioner, Shan States. At that time "even their names were uncertain, much more their extent, population, languages and the habits of the people," and "Taunggyi had not even been heard of." In the vast extent of his jurisdiction "there were not merely no carts, but there was not even a road. Everything went along the river bed—sepoys, Tommies, mountain guns . . ." but before the end of 1888 the mission had succeeded in transforming "some two or three million excited and rebellious Shans scattered over an area of nearly 80,000 square miles of difficult country into loyal subjects, and had done so without resort to actual military operations."

Throughout the book there are vivid little pen-pictures, such as Scott's description of the scene when the Sawbwa of Thaton came to make his submission. "At five, round with the flag to the large open space in front of the palace. The bugle sounded the salute. Captain Waller's fifty rifles presented arms as I ran up the flag rigged on a rope on a huge bamboo. The Sawbwa's band broke into a triumphant measure. The entire population bowed down and did obeisance to the new flag and the new Suzerain thus established in the Shan States."

As one turns the pages one calls to mind those peaceful Shan hills and valleys and the little brown houses amid the waving bamboos, the numerous roads

suitable for motor traffic and the excellent mule-paths, and cannot help contrasting the country now with what it was in Scott's time, when he toiled along in mud so deep that "every step sank in and up to the knee and one had to extract one's leg like a cork from the bottle," soaked by rain or blistered by the sun, meeting often with hostile receptions when bullets spattered the little party. One is amazed at the physical strength of the man himself, as well as at his personality and the tact with which he persuaded the reluctant Sawbwas to acknowledge the British Raj.

In chapter X there is a spirited description of Scott's journey into the states of the head-hunting Wild Wa, a country hitherto unpenetrated by Europeans. His mission was to obtain the formal submission of Tong Sang, an important chief who, though himself a Wa, ruled over Shans. The Wa believed that without a skull nothing would go right: their crops would fail, their cattle would die, their *nats* would be shamed. The head-hunting season opened in March and lasted for two months. The skull of a Lem Shan was worth only two rupees, while a Chinaman's would fetch thirty rupees and a Burman's fifty.

After the successful conclusion of the Wa expedition Scott was appointed Minister Resident at Bangkok. Before however he had been there a year, he was ordered to proceed on the Buffer State Commission to deal with the delicate situation which had arisen over Keng Cheng, a Shan State bordering on British, French, and Siamese territory.

In October 1898 Scott took over the duties of British Commissioner of the Burma–China Boundary Commission, and the chapters describing "this baffling job" are among the most interesting in the book. Two years later he was permitted by the Government of India to proceed to Peking to study Chinese. It was a most interesting time; the besieged Legations had not long been relieved, the Empress Dowager had fled with the Emperor from Peking, and the city and palaces were occupied by the Allied forces. In the Birthday Honours List in 1901 Scott was awarded the K.C.I.E., and early the following year he was appointed Superintendent, Southern Shan States. In spite of his busy travelling life Scott found time to compile that invaluable work in five volumes, 'The Upper Burma Gazetteer,' and to write several books, of which the best known is 'The Burman: his Life and Notions,' published under his Burmese name of Shway Yoe.

Twenty-six interesting photographs and three helpful maps are included in this work. B. M.

INDIES ADVENTURE: The amazing career of Afonso de Albuquerque. By ELAINE SANCEAU. *London: Blackie & Son*, 1936. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* x+308 *pages; illustrations, map, and plans.* 12*s* 6*d*

The first part of the title is unsuited to the subject, but it has probably been chosen to attract the general reader. The book offers a full and accurate account of extraordinary achievements and though written in vivacious language it is a good specimen of a modern popular biography. It includes eleven most appropriate illustrations, a chronology of Albuquerque's career, but no index. Miss Sanceau does not claim to have presented new facts and describes her work as little more than a paraphrase of the chronicles, checked and supplemented by the letters of Albuquerque and innumerable contemporary papers. The materials relating to Albuquerque have been printed in seven volumes, of which the first contains the Governor's Letters to King Manuel, the others being filled with thousands of documents, forming evidence of his wonderful activity. After an interval of twenty years the last volume, with an index, has just appeared. These letters and documents are primary authorities and they are supplemented

by the *Commentaries* composed by Albuquerque's son and by general histories, especially those of Castanheda and Gaspar Correa. Miss Sanceau rightly bases her narrative on these men, quoting largely from the Letters and Chronicles though without giving reference to work, volume, or page: an omission which diminishes the value of the book. Where we have checked her translations, they are correct, which is to her credit, because the Letters were dictated to secretaries, often hastily, seemingly not corrected before signature, and their meaning is not always clear.

Miss Sanceau has caught the spirit and penetrated the character of Albuquerque and she furnishes a large amount of information about him without apparent effort. He was a man of lofty vision. Bent on winning for his country the control of the trade from east to west, he recognized the strategic points, Ormuz, Malacca, Aden, and Diu. He seized the first two; his attempt on the third failed by an accident; he had not the chance to capture the fourth, and it only became Portuguese some twenty years after his death. His choice of Goa as capital of the State of India, stretching from East Africa to Malacca and later on to the Moluccas, could not have been bettered. As a military commander he was equally successful by sea and land: the naval battle at Ormuz, the capture of Malacca and the siege of Benastarim, audacious ventures, each presenting different problems, are the examples. A man of quick temper, he manifested a rare patience and generosity towards undisciplined captains and incompetent officials, and when enemies calumniated him to the King he defended himself but set down their good qualities. His self-control was put to the test during long periods: in the blockade of Ormuz, again when the Viceroy refused to hand over the government and even imprisoned him, and finally when the monsoon kept his fleet for months in Goa harbour in 1510 and his crews were starving. A man of his wide interests could not overlook the natural features of the lands and seas he visited, though political rather than scientific motives led him to study them. During his expedition to the Red Sea in 1513 he personally explored some of its bays and islands, explained to the King the reason of its name, and told him that the key of the strait was Aden and not the entrance.

Miss Sanceau says little of his diplomatic and administrative work or of his development of trade, which his exacting King had most at heart. The first was studied at length by C. Roque da Costa in his "Historia das relações diplomaticas de Portugal no Oriente," printed in the *Bulletin* of the Lisbon Geographical Society for 1894, while Albuquerque's naval operations have been described in detail by Admiral Ballard in 'Rulers of the Indian Ocean.' E. P.

GEORG WILHELM STELLER: The pioneer of Alaskan natural history. By LEONHARD STEJNEGER. *Cambridge, Mass.: Harvard University Press (London: Oxford University Press)*, 1936. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xxiv+624 *pages; illustrations and route-maps.* 25*s*

Among the many Germans and Scandinavians who helped in the discovery and exploration of Siberia and Alaska, Steller's name stands out as one of the greatest. He was the first white man to cross the fog-bound seas between Russian Asia and America and was the first to set foot on Alaskan soil. No complete account of his life has yet been written at any rate in English, and Dr. Stejneger has been successful in producing a biography of intense human as well as scientific interest.

Steller, whose name was really Stöhler, was born in the free Imperial City of Windsheim, about 34 miles west of Nürnberg, in Bavaria, in 1709. He was educated at the Universities of Wittenberg, Halle, and Berlin where he studied

natural history, especially botany and medicine. After some wandering he finally obtained a passage to St. Petersburg as medical officer of a transport carrying sick and wounded Russian soldiers.

Not more than ten years had passed since Peter the Great had died, and Russia was still in a state of transition between the semi-Asiatic Tsardom and the modern autocratic empire, but Steller found a good many friends and supporters among the educated Germans connected with the Academy of Sciences which, though planned by Peter the Great, was not founded until 1726, shortly after his death. Just before this occurred Peter had selected Fleet-Captain Bering to lead what is known as the first Kamchatkan Expedition, during which he proved that Asia was not connected with America though he never saw the latter continent.

A second expedition was planned to complete the exploration of the northern Pacific and what is now known as Bering Sea, in 1733, also under Bering, who was a Dane by birth. It was a joint affair partly controlled by the Admiralty and partly by the Academy so far as the scientific part of the work was concerned. In 1737 Steller was appointed as "adjunct" to devote himself to natural history for the duration of the expedition. He travelled east through Siberia to Kamchatka, where he conducted some preliminary exploration, and in 1741 he joined Bering at Petropavlovsk in Avatcha Bay and set sail with him on his memorable voyage in the *St. Peter* on April 22 of that year. This ship was the first to cross the northern Pacific, and on July 16 Steller and Bering reached Alaska where the majestic Mount St. Elias, as yet unnamed, raises its snowy peak of 17,978 feet. They stayed but a short time, as Bering was ill and scurvy had commenced to ravage the crew. Eventually they found their way back to an island off the coast of Kamchatka, afterwards named Bering Island; nearly all the crew were down with scurvy, and there they wintered. Bering died in December and was succeeded by Waxell, the second-in-command. The *St. Peter* was driven ashore and wrecked, but a new ship was built from the materials of the wreck, in which all the survivors, including Steller, reached Avatcha Bay in August 1741.

During his stay on Bering Island, Steller spent all his time exploring, collecting, and describing the remarkable animals and birds found there. Of these the most interesting was the Sea Cow, *Rhytina stelleri*, but more correctly *Hydrodamalis gigas*, a large representative of the manatees and dugongs of tropical waters. They were herbivorous, feeding on the gigantic seaweeds which are found on the coast of the island. They were easy to catch and good to eat, and large numbers were used for food by the scurvy-ridden crew. All our knowledge of this remarkable animal is derived from Steller's account, as it became extinct a few years later and, apart from skeletons, the only portions of the animal still extant is the horny masticating plate of the palate now in the Leningrad Museum. His other discovery was the fur-seal, which arrives in spring to breed on certain islands in Bering Sea and is the source of the valuable sealskin fur, also the sea lion and the sea otter. These four animals were all described by Steller in his 'De bestiis marinis,' published after his death by the Academy at St. Petersburg.

Steller travelled back from Kamchatka to Russia as far as Solikamsk in the Perm Government, where he was hospitably received in the house of one of the Demidov family, a patron of science and specially interested in botany. Here he was suddenly placed under arrest on a mysterious charge of high treason and ordered to return to Irkutsk in Siberia to stand his trial. Before he got there however he received another message informing him that he was a free man again. He was now far from well, though it seems uncertain what

he was really suffering from. He died at Tyumen in Siberia, on his way back west again, on 12 November 1746.

Dr. Stejneger, who has recently vacated the post of Head Curator of Biology in the United States Natural History Museum at Washington, has followed in Steller's footsteps. He made a journey to Bering Island in 1882 and subsequently visited the scenes of his hero's Kamchatkan-Alaskan activities. He has also made a pilgrimage to his native city in Bavaria to investigate the details of his early life, and has altogether amassed a vast amount of new information, not only about Steller but about his contemporaries. He has put all this matter together in a narrative of extraordinary interest, and it will form a worthy monument to one who truly merits the title of the Pioneer of Alaskan Natural History.

The volume is well illustrated with maps and portraits, though unfortunately there appears to be no extant picture of Steller himself. Our only serious criticism is that the route-map of Steller's travels is unworthy of the work: it has been so reduced by photography that it is almost impossible to read except with a strong glass. So excellent a travel book might well have been better furnished. W. L. S.

GENERAL

HARPOONER: A four-year voyage on the barque *Kathleen*, 1880–1884. By ROBERT FERGUSON. Edited by LESLIE DALRYMPLE STAIR. *Philadelphia: University of Pennsylvania Press* (*London: Humphrey Milford*), 1936. 8½×6 *inches;* xvi+316 *pages; illustrations and route-map.* 11*s* 6*d*

The author of this diary was a harpooner on the barque *Kathleen*, of New Bedford, from 1880 to 1884, previous to which, after many years before the mast and on the bridge, he had spent a year, including a wintering, in Arctic whaling. On many of his voyages he kept full diaries, of which this one dealing with whaling in the Atlantic has been chosen for publication. Mr. Ferguson seems to have been a staunch, fearless seaman, a little austere in his outlook, but showing the grit and determination of his highland forbears. Much of the diary records trivial incidents of daily life and events in ports which are not of great interest, but it gives glimpses of Tristan da Cunha and St. Helena, and other little-known islands in the Atlantic and Indian Oceans. St. Helena especially is a focus of interest, and we hear of as many as twenty whale ships lying at anchor off Jamestown. There are a few exciting incidents such as an attack by Malay pirates, encounters with savage whales, and a long journey in an open boat, but it is a little disappointing to find so few details about the actual whaling, and next to nothing about the habits of whales. Sperms were the chief quarry, but humpbacks and "right" whales were also caught. Frequently however the record of a "kill" specifies no particular kind of whale. There are some admirable woodcuts and a useful map, but the book as a whole, while making pleasant reading of some little historical value, is not a contribution of moment on the subject of whaling. R. N. R. B.

THE MONTHLY RECORD

SUMMER FLOODS IN SONOYTA VALLEY, MEXICO

An account of intense summer storms over small areas in the desert region of Sonora state, north-west Mexico, is given by Mr. Ronald L. Ives in a paper entitled "Desert Floods in the Sonoyta Valley," appearing in the *American Journal of Science* for November 1936. The Sonoyta Valley is the most westerly of a series of similar valleys extending from a point east of Nogales to the Gulf of Mexico. These valleys run up into the Sierra de Cubabi mountains, each range of which has a definite pediment whose extent into the several valleys bears an apparent relation to the elevation of the range above the valley floor. Thus for the granite ranges of this area there seems to be about half a mile of pediment for each thousand feet of average elevation above the valley floor. The valleys are typical desert valleys, and their drainage ends in playa depressions instead of reaching the Gulf of Mexico. In the Sonoyta Valley the mean annual rainfall is only 8 inches, though limited areas receive much more. The bulk of this amount is brought by a monsoon current from the Pacific between the middle of August to the middle of September. The rain comes in sudden torrential localized storms which often inundate the town of Sonoyta and bring down much detritus from the mountains.

During the flood season clouds drive inland from the Pacific, drop much of this moisture in crossing the peninsula of Lower California, acquire more moisture in crossing the Gulf of California, and drift inland along definite paths till on approaching the mountain ranges they precipitate much of their moisture again. A typical storm cloud will cross the peninsula of Lower California early in the morning, and by noon will be over the Gulf. Here it pauses, becoming larger and blacker. During the early afternoon it again advances eastward over the Sonoran mainland till caught up by powerful convection currents near one or other of the dominant mountain ranges at the head of the Sonoyta Valley. Then at an elevation of between 600 and 8000 feet a cloudburst with violent thunder and lightning will occur, the run-off from the downpour becoming a *sheet-flood* on reaching the pediment of the range, a *stream-flood* on reaching the channelled valley, and a *playa-flood* on reaching the bottom of the valley. This type of flood brought by moisture from outside the valley is distinguished as a primary flood. It happens sometimes however that soon after the playas have been flooded the water in them is rapidly re-evaporated by the hot sun with formation of cumulo-nimbus clouds which move irregularly in the valley and bring local storms. This type of flood being of local origin is distinguished as a secondary flood. The secondary storms are more erratic and less violent than the primary storms, and generally cause only playa and stream floods, seldom reaching as far as the pediment.

GLACIATION OF THE BANTRY BAY DISTRICT

The counties of Cork and Kerry, noted for their particularly mild climate, were heavily glaciated during the Pleistocene Ice Age, and lay beneath an ice-sheet which was separate from the main Irish ice. Evidence of past glaciers in the south-west of Ireland was recognized as far back as the middle of last century, but there has been little detailed study of the area. Hence a paper by Mr. A. Farrington entitled the "Glaciation of the Bantry Bay District" in the *Scientific Proceedings of the Royal Dublin Society* (vol. 21, September 1936), is of interest. The evidence for what is considered to have been the last glaciation in the district is abundantly supplied by rock striae, various types of drift

including an extensive system of drumlins, erratics, and glacial drainage channels or "dry gaps." Bantry Bay, some 20 miles long and 5 wide, is, except where open to the sea, completely surrounded by mountainous land. The predominant rock is Old Red Sandstone, but erratics of Carboniferous Limestone point to an outlier of this rock beneath the waters of the bay. Bantry Bay is separated from the Kenmare estuary to the north-west by the Bear Peninsula which is traversed by the Slieve Miskish and Caha mountains. The Caha plateau is studded with small lakes lying in rock hollows dammed in some cases by rubbly morainic drift. Here the rock-slabs are heavily scored with grooves and scratches up to 15 feet in length, and on the less weathered ground the edges of these still feel sharp to the touch.

From all the evidence at hand, especially the general direction of the striae indicated in an accompanying folded map, and the orientation of the drumlin hills, shown in a sketch-map to be particularly numerous on the south shore of the bay, it is concluded that the area around Bantry Bay was invaded by ice coming from the north-north-west over the Caha and Miskish highlands which were overwhelmed up to a height of 2000 feet. The bay was filled with ice, which escaped south-westward along the bay, north-eastward up into the mountain valleys where fine terminal moraines are found, and south-eastward as far as Skibbereen. The pressure of ice coming down the Glengarriff valley caused congestion at the head of the bay, and there was much differential movement within the ice mass. Drumlin trains follow the north-eastward and south-westward ice movements, but only to a small extent that which took a south-eastward direction.

The centre of dispersion of the ice-sheet affecting Bantry Bay was the Kenmare estuary, from which ice pushed in the opposite direction over the flanks of the McGillicuddy's Reeks up to a height of 2000 feet. Whereas the upper part of the ice-mass advancing across Bantry Bay preserved a general direction of motion towards the south-east, the movements of the lower parts were controlled by the configuration of the land.

The author is a geologist, and practically his only reference to the meteorological side of the subject is a very obscure statement to the effect that though the Bantry Bay glaciers were fed almost entirely from the area of accumulation in the Kenmare estuary "there may have been some precipitation on the higher parts at the maximum phase of the glaciation." It is important to emphasize however that there are meteorological indications of very heavy snowfall throughout a moist region like the south-west of Ireland under the cold climatic conditions in question. Even in the mild climate of to-day snow is liable to fall more copiously during occasional spells of cold weather in Southern Ireland than in some of the colder and less rainy eastern parts of the British Isles.

RAINFALL MAP OF YUGOSLAVIA

To their series of physical maps of Yugoslavia the Geographical Society of Belgrade have recently added a map of the average annual rainfall by H. Renier (Collection de cartes, No. 4). The map, which is on the scale of 1/1·2 M., is very clearly printed in colour. By a careful selection of tints, the three main rainfall regions, approximately parallel to the Adriatic coast, are well distinguished. Up to 800 mm. the tints range from orange to pale yellow; from 800 to 1600 mm. shades of light blue are used; and from 1600 to 3000 mm. and above shades of dark blue. The three areas thus shown correspond to the seaward portions of the coastal ranges, the eastern section of these ranges, and the valleys of the interior. The two areas of maximum rainfall lie along the coast south of Sušak and around Cetinje; the most conspicuous area of minimum rainfall

extends south-east from Skoplje along the upper Vardar basin. The production and style of the map reflects much credit upon the State Printing Office at Belgrade.

BIBLIOGRAPHIE GÉOGRAPHIQUE INTERNATIONALE, 1935

The forty-fifth annual volume of the Bibliographie Géographique Internationale, dealing with literature published during the year 1935, has now been published, and will be distributed this month by the Society to subscribers in the British Isles and the Dominions. The volume of 632 pages contains about eight thousand references to books and articles of geographical interest, many of which are accompanied by short abstracts. By arrangement with the Association de Géographes français, the Society is able to supply the bibliography at a reduced price. This year, partly on account of the present rate of exchange, the volume will be distributed at the price of 10*s.* 6*d.*, post free, as compared with 15*s.* for the 1934 volume. Orders should be sent to the Office of the Society. Volumes for the years 1924 to 1934 can in most cases still be obtained from the Society at special prices.

RECENT GEOGRAPHICAL INDEXES

General indexes to three important geographical periodicals have recently been published, and should be noted by students of geography. The Royal Scottish Geographical Society have issued a general index to the first fifty volumes, 1885–1934, of the *Scottish Geographical Magazine*. This has been compiled from the annual indexes, and lists alphabetically the titles and authors of papers, longer reviews, and those geographical notes which relate to Scotland. No typographical distinction is made between the various types of entry. Maps have been brought together under that heading and arranged topographically. A useful, though minor, point is the insertion, where possible, of the date of birth and death after each entry in the obituaries.

The index to the *Geographical Review*, volumes 16 to 25 (1926–35), has been compiled by Mr. A. A. Brooks upon a more detailed plan. In addition to author and subject entries for articles, notes, reviews, and maps, the contents of the volumes has been analysed, and topographical and personal names entered. Notes, reviews, maps, and illustrations are distinguished in the references. The whole is arranged in one alphabet, with no attempt at regional grouping, *e.g.* Central America, Hispanic America, and Latin America are entered under those headings. Once this principle is grasped it makes reference easy, but something might be gained by grouping such regions together under the main heading America.

The third is the "Inhaltsverzeichnis" to *Petermanns Mitteilungen* for the years 1905 to 1934, which covers thirty volumes of the *Mitteilungen* and seventeen volumes of the *Ergänzungsbände*. In this a strictly regional and subject arrangement has been adopted. The two main sections, articles, notes on journeys and research, etc., and reviews of geographical literature, are classified by continents, countries and, frequently, smaller subdivisions, the final order being alphabetical by authors' names, so that all entries on adjacent areas are brought near each other. There is no author index to the first section, *i.e.* the contributions to the *Mitteilungen;* an index of authors of books reviewed is provided, with references to the volume and number of the review, but without giving the titles of the books. In the case of a prolific author it may be necessary to look up a number of references before finding the required title. No doubt considerations of space have led to these limitations—the index has 402 pages—but a short introduction stating the principle followed would have been of use

to the student. The volume concludes with a classified index to the maps published in the *Mitteilungen* and *Ergänzungsbände*, with four folding plates of maps, showing the areas covered by the sheets.

MONOGRAPHS ON ECONOMIC GEOGRAPHY OF POLAND

The Birmingham University Information Service on Slavonic Countries has published the first two of four projected monographs on Poland: 'Poland: Human and Economic Characteristics in their Geographical Setting.' In the first monograph (pp. 16), after drawing attention to the lack of well-defined eastern and western boundaries and its influence on Polish history, Mr. R. H. Kinvig describes the geographical background: the Carpathians, the southern plateau, and the central and northern lowlands. He devotes a short section on climate and natural vegetation. There are four maps showing relief, division into voivodships, population density (1931) and the composition of the population. The latter is particularly interesting in view of the fact that only 69 per cent. of the population are Poles, the remaining 31 per cent. being composed of five different nationalities, excluding the Jews. In the second monograph (pp. 20), Mr. Kinvig gives a short sketch of the history of Poland, and then deals with the composition of the present population. Finally, he summarizes the history of Polish economic development, under the headings of agriculture, industry, communications, and trade. There is a map to illustrate the Partitions, and two maps to show the distribution of crops and the major industries. There are ample footnotes and a lengthy bibliographical note to Chapter I. As the monographs are meant for "the citizen who has not got time to master the material, but desires to understand, from a competent guide, the main features of the country," it is a pity that the maps (with two exceptions) are entirely bereft of the names of rivers and cities: a feature which detracts particularly from the value of the political and population maps.

OBITUARY

JOHN HARDWICK REYNOLDS

Mr. J. H. Reynolds was a Queen's Scholar of Westminster School and Scholar of Christ Church, Oxford. By profession he was an architect, who, in the early days of the Great War, joined the voluntary staff of the Society and was soon absorbed into the organization that compiled more than a hundred provisional sheets of the 1/Million map of Europe and the Near East. He had developed two talents: the construction of simplified contours from complex material, and the transliteration of place-names from Slavonic and Oriental languages. When therefore in 1919 it was resolved, at the instigation of the Board of Admiralty, to form a Permanent Committee on Geographical Names for British Official Use, he was very naturally called upon to assist, and soon became the Secretary and the one-man permanent staff of the Committee. He worked in the Society's House, in the room placed by the Council at the disposal of the P.C.G.N., and was responsible to the Committee, and in particular to its Chairman, Major-General Lord Edward Gleichen. As Secretary of the P.C.G.N. Mr. Reynolds gave devoted service to geography, being mainly responsible for compiling the Lists which have done so much to regularize the

spelling of place-names on British official maps and commercial atlases, and in this *Journal*. In the course of years he acquired a vast knowledge of world alphabets and ideographs, of systems of romanization successful and unsuccessful, of the transformations which a name may undergo by successive transliteration; and he had a clear and constant judgement in keeping to strict principles without pedantry. When a List, General for a Continent or Special to a country, was submitted by him in proof to the Permanent Committee, they had always the case well prepared for them in advance and had little to do other than to settle individual difficulties. His 'Alphabets of Foreign Languages,' published as R.G.S. Technical Series No. 2 (2nd Edition 1933), is an indispensable guide in a field full of pitfalls. In 1924 he received the Murchison Award for these important services to geography.

For ten years Mr. Reynolds gave his whole time to the work of the P.C.G.N. When its progress was to some extent impeded by lack of funds, he became Joint Editor, in 1931, with Captain McCaw of the *Empire Survey Review*. His wide and detailed knowledge of Great Britain is shown in the many reviews he contributed to our *Journal*.

Some two years ago his health became seriously impaired and he had to suffer a series of operations, but was able in the intervals to continue his work for the P.C.G.N. with his old efficiency if not with his former strength and energy. Until a few weeks ago he was better, and was making the plans for important developments in the publications of the Committee, made possible by a renewed grant from the Treasury. It is a tragedy that at this moment he was smitten with renewed illness and died on January 9, to the grief of his colleagues and friends.

MEETINGS: SESSION 1936–37

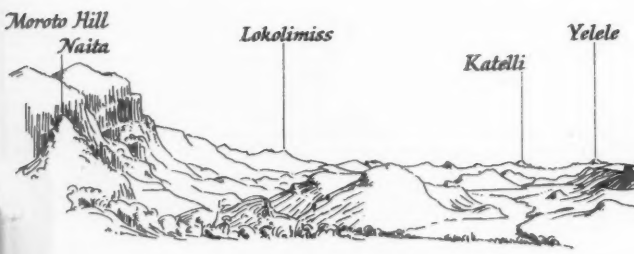
Fifth Evening Meeting, 11 January 1937. Admiral Sir William Goodenough in the Chair

Elections: Ronald James Bowker; Anthony Malcolm Buckeridge; V. C. Buckley; George Humphrey Cheshire; Oliver Herbert Chilton, M.SC., A.M.I.C.E.; Robert H. Crease; Richard Gordon Goode; Miss Mabel Hall, B.SC.; Jonas Hanson; William Johnston; Gerald Kingsley; Miss Blanche Lelasseur; Miss Dorothy Lungley; Mrs. Fraser McDonell; Mrs. Wagner MacMillan; Alexander Frederick Martin; Miss Beatrice Marsinah Neison; Claude Leon Pickens, Junr.; Miss Irmgard Plutte; George William Rayner, M.SC.; Lieut.-Col. William Percy Newport Ridley, T.D., D.L.; Basil Eugene Ewbank Taylor; Emile Vaillancourt; Edgar Barton Worthington, M.A., PH.D.

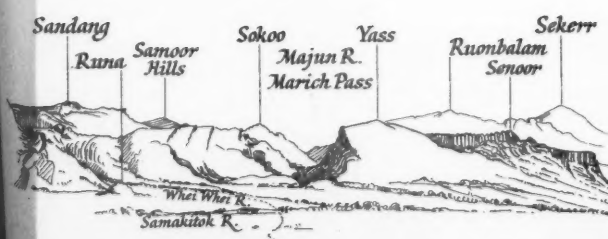
Paper: From the Brahmaputra to the Chindwin. By Mr. E. T. D. Lambert

Fourth Afternoon Meeting, 18 January 1937. The President in the Chair

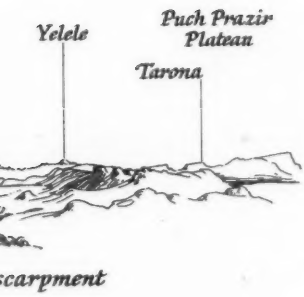
Paper: Climatic Cycles. By Professor David Brunt



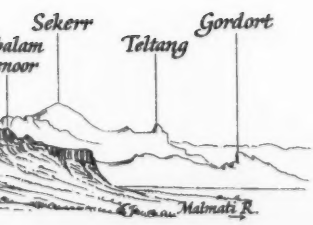
Western Rift Wall from Suk Escarpment



Western Rift Wall from Ckikasol in the Masol



scarpment



the Masol Range

A N34°G L O - E G Y P T

Recently discovered lake

5°

Lomayen R.

Lotogippi

Nathei

Mt. Mogilla

Nanaam R.

Zulia

Mt. Zulia

Kortieng

Zingout

4°

NORTHER

Lokolopus Hills

A

D

•Kakamari

Kameringor

Tarash

Lokiriama•

Lukusukeny

Yelele

3°

Puch Prazir

N

Moroto•

Moroto Hill

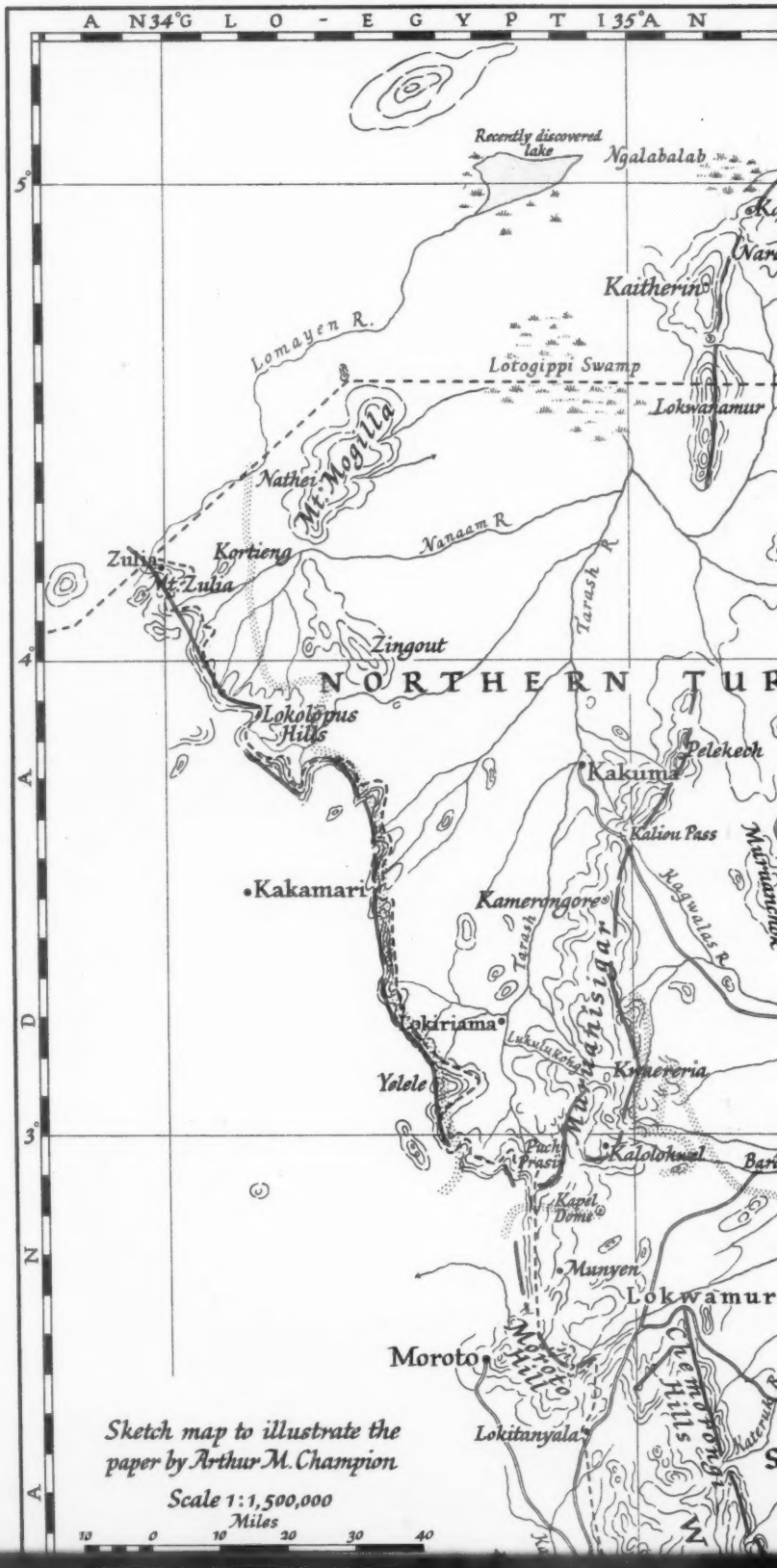
Lokitanyala

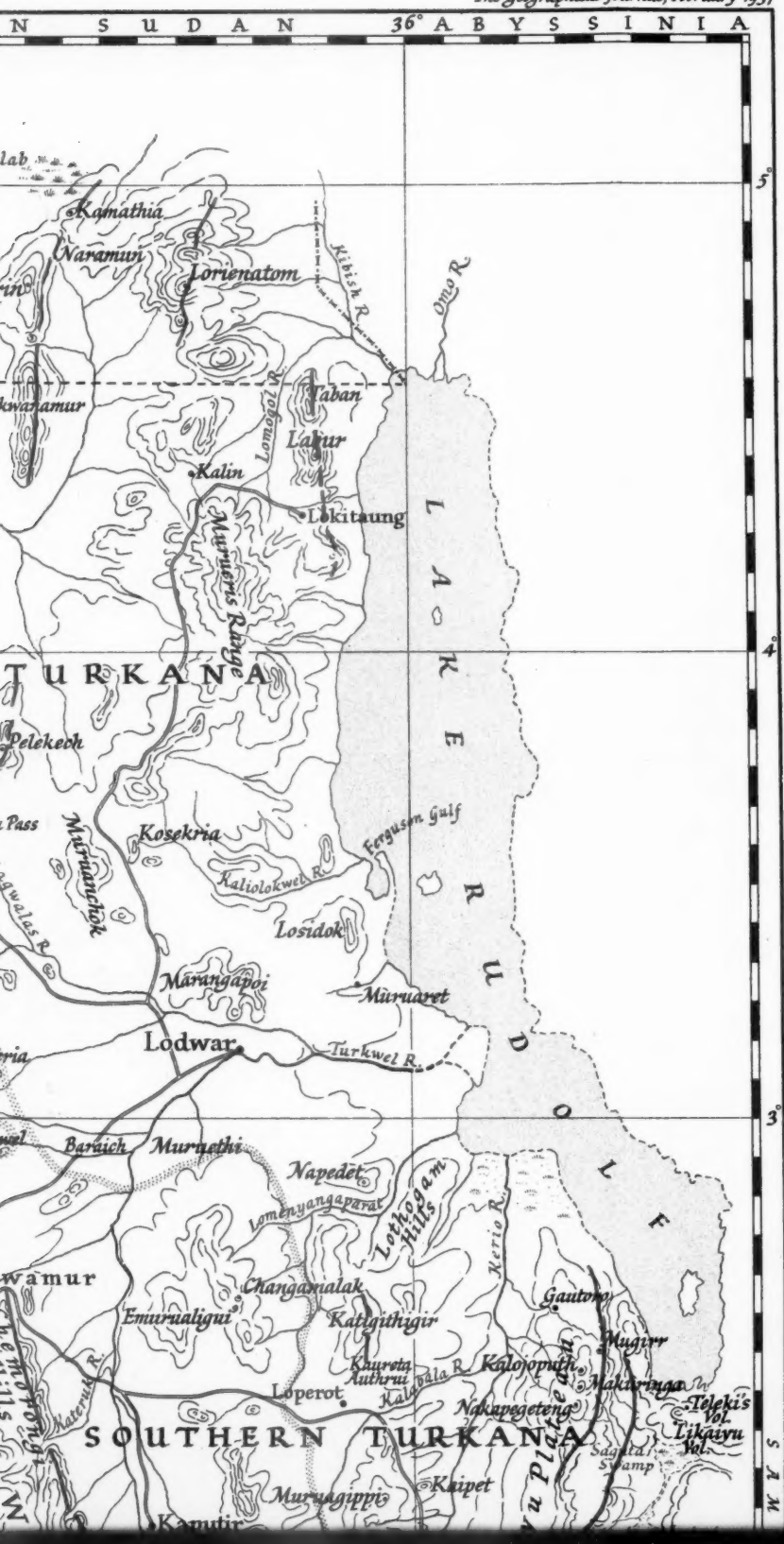
A

Sketch map to illustrate the paper by Arthur M. Champion

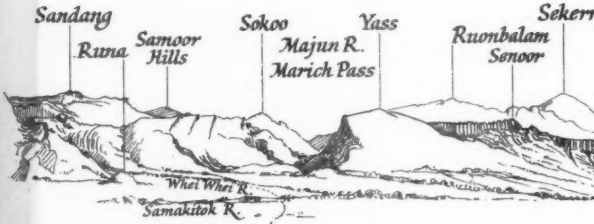
Scale 1:1,500,000

Miles


ANGLO-EGYPTIAN
34°
35°
5°
4°
3°
Recently discovered lake
Ngalabalab
Kaitherin
Lomayen R.
Lotogippi Swamp
Lokwamamur
Nathei
Mt. Mogilla
Nanaam R
Zulia
Mt. Zulia
Kortieng
Zingout
Tarash R
NORTHERN TUR
Lokolopus Hills
Pelekech
Kakuma
Kaliou Pass
Kakamari
Kamerongore
Tarash
Kagwalas R
Lokiriama
Yolele
Kapedo
Kalolokwal
Kapel Dome
Munyen
Lokwamur
Moroto
Moroto Hill
Lokitanyala
Sketch map to illustrate the paper by Arthur M. Champion
Scale 1:1,500,000
Miles
10 0 10 20 30 40

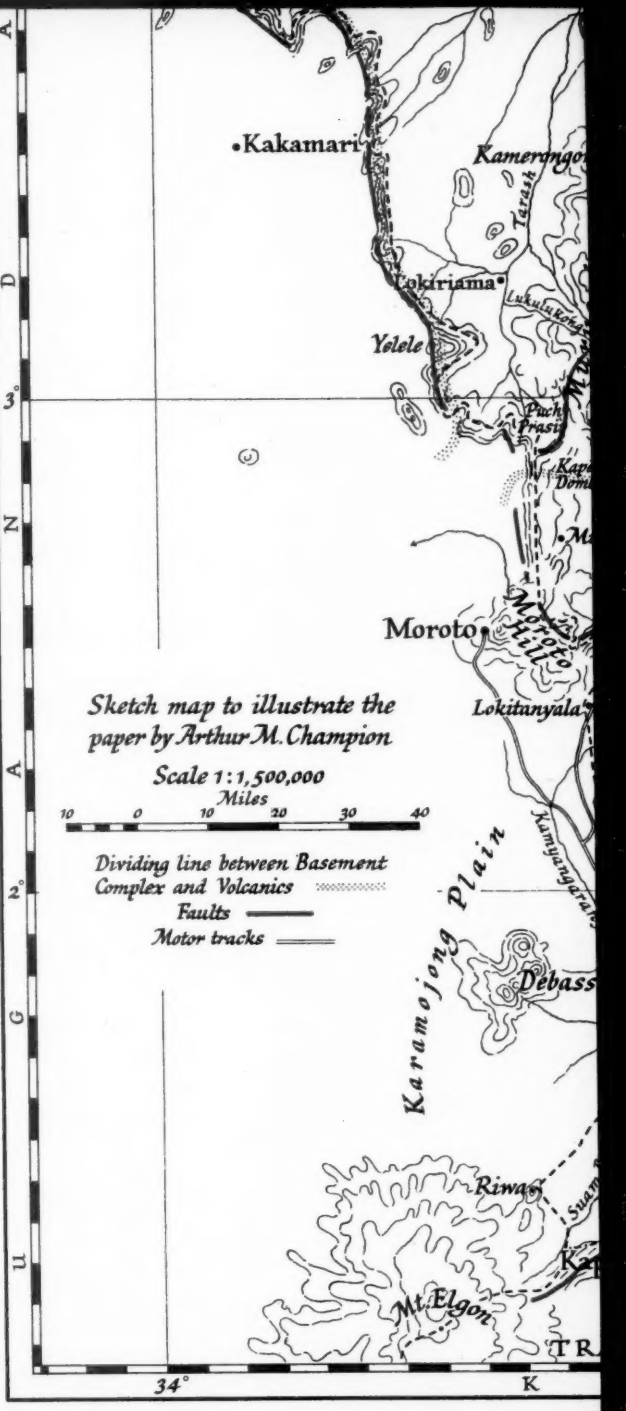

N S U D A N
36° A B Y S S I N I A
5°
4°
3°
Kamathia
Naramuni
Lorienatom
Kibish R.
Omo R.
Lomogol R.
Taban
Lakur
Kalin
Lokitaung
Murungis Range
L A K E R U D O L F
T U R K A N A
Pelekech
Kosekria
Ferguson Gulf
Kaliolokwel R.
Losidok
Murangapoi
Muruaret
Lodwar
Turkwel R.
Baraich
Murnethi
Napedet
Lomenyangaparat
Lothagam Hills
Kerio R.
Changamalak
Emurualigui
Katigithigir
Gautoin
Mugirr
Kalojoputh
Makaringa
Teleki's Vol.
Likaiyu Vol.
Loperot
Nakapegeteng
S O U T H E R N T U R K A N A
Sagata Swamp
Kaipet
Murungippi
Kamutir
SAM

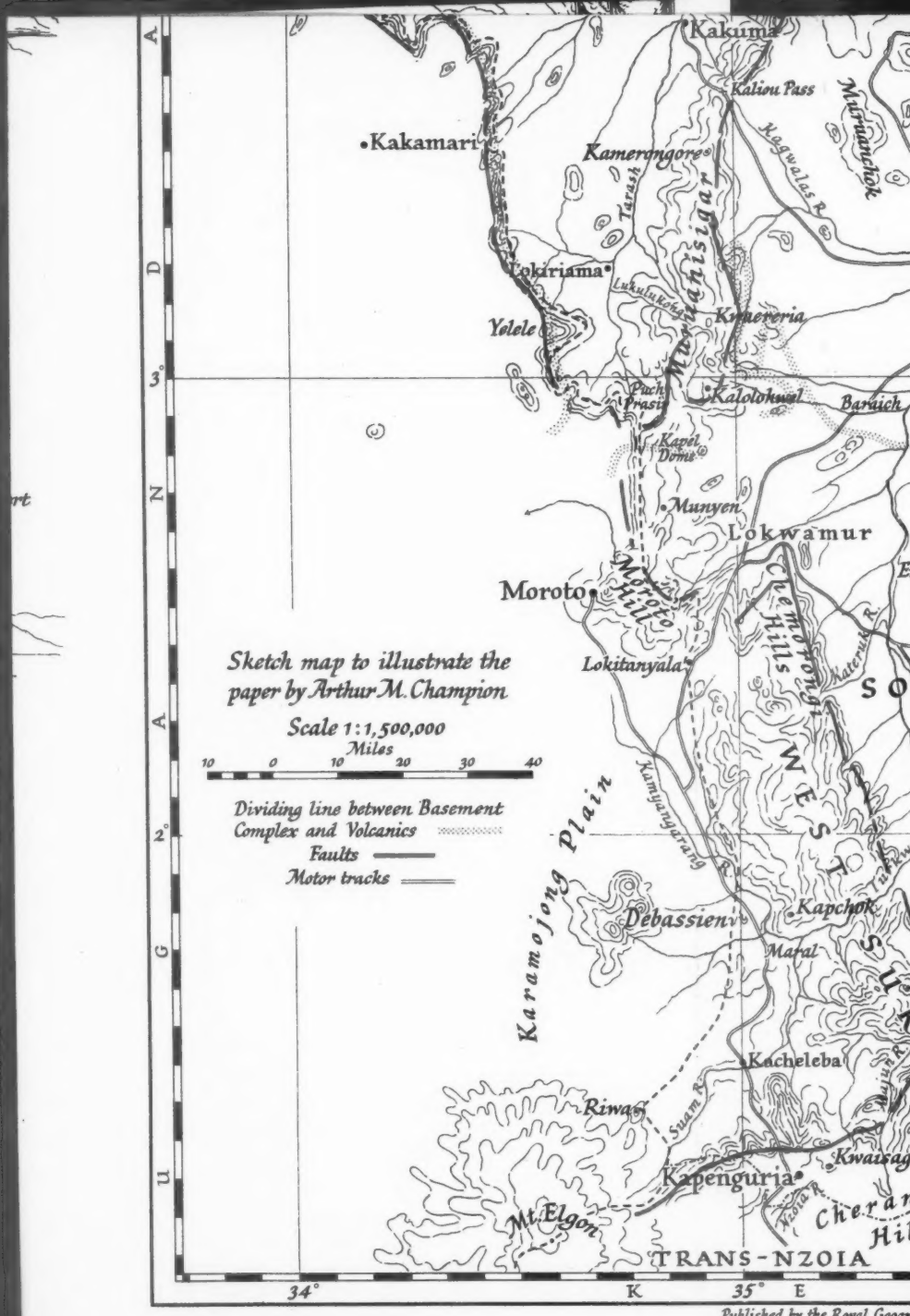
Western Rift Wall from Suk Escarpmen



Western Rift Wall from Ckikasol in the Mas

in the Masol Range





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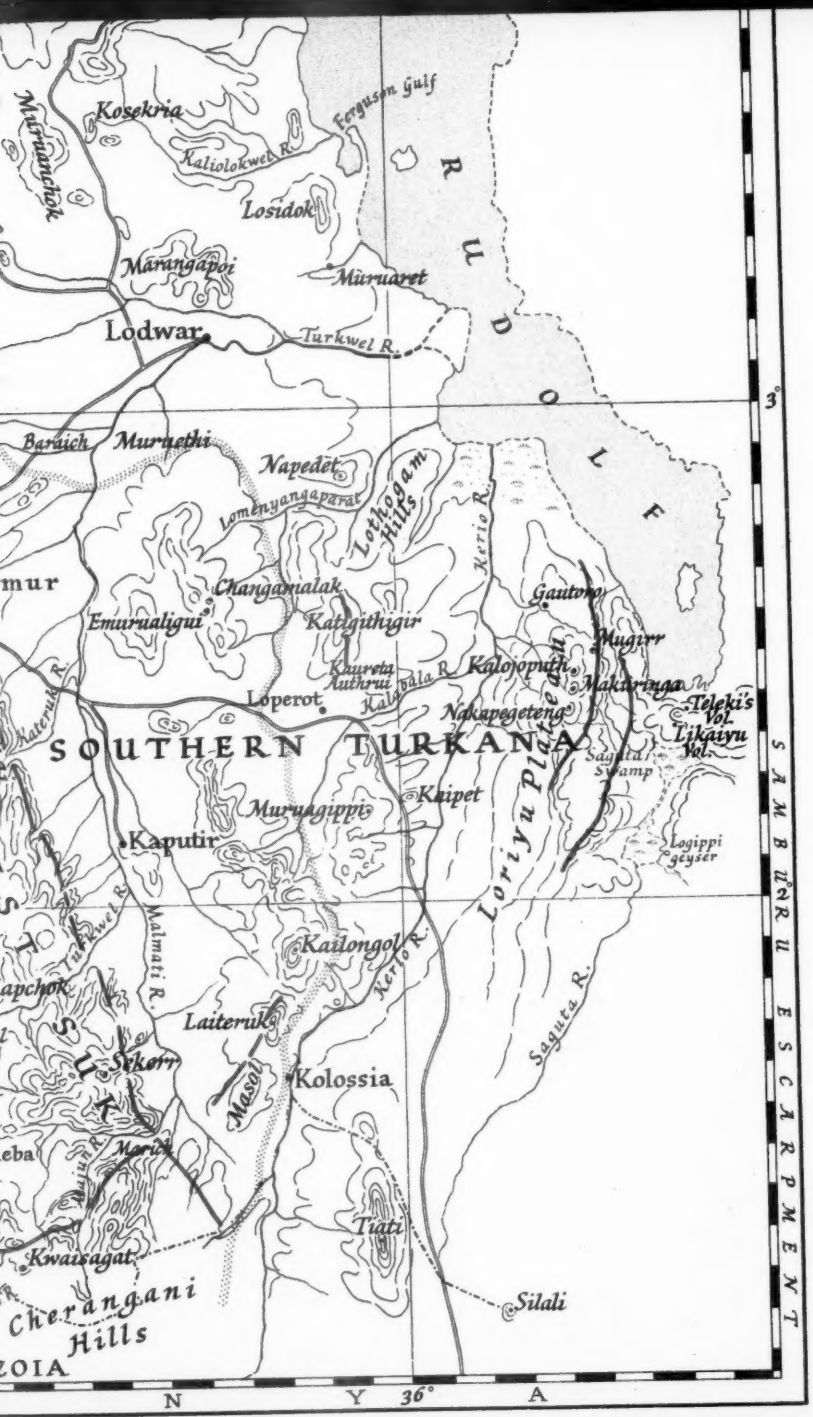
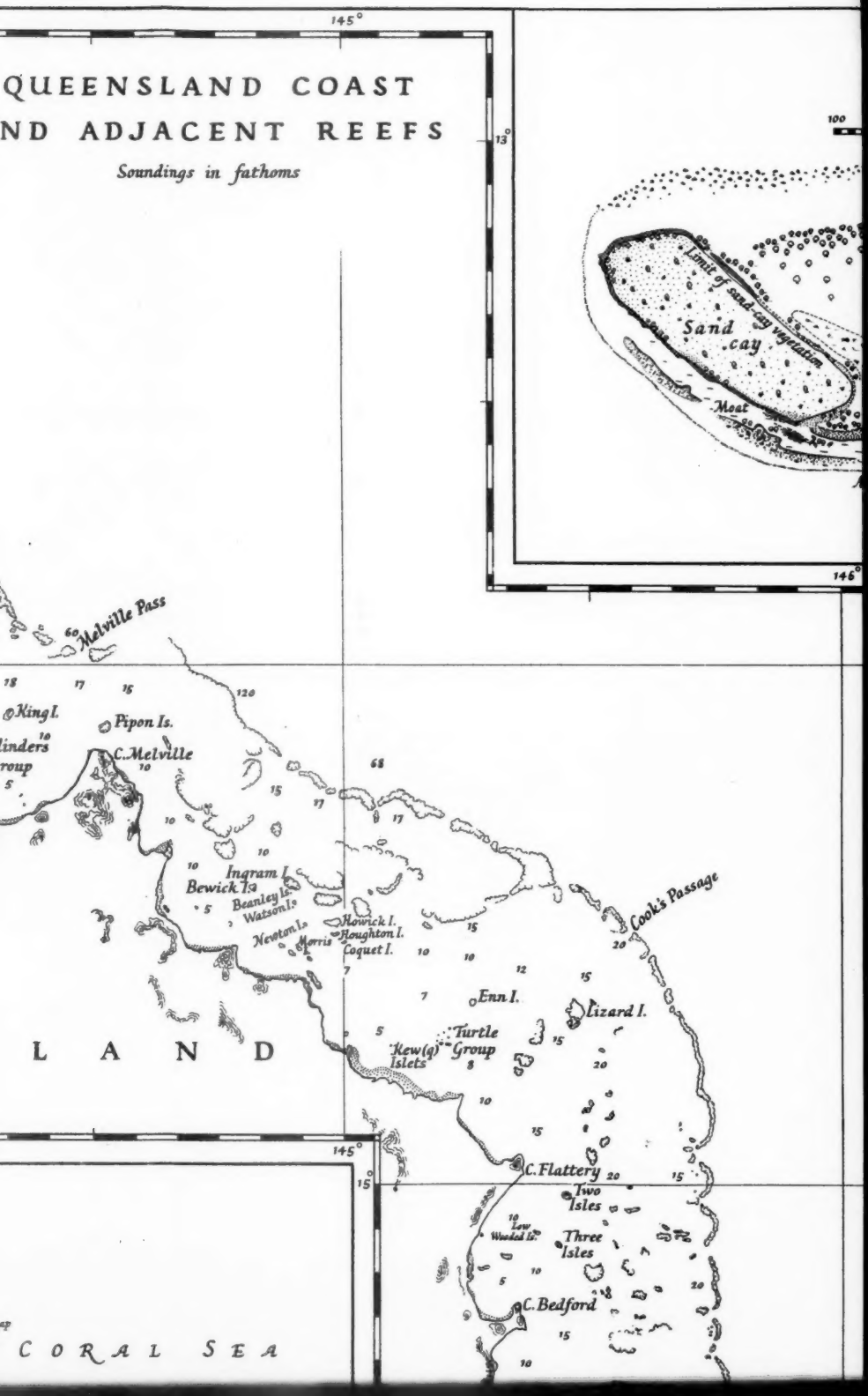
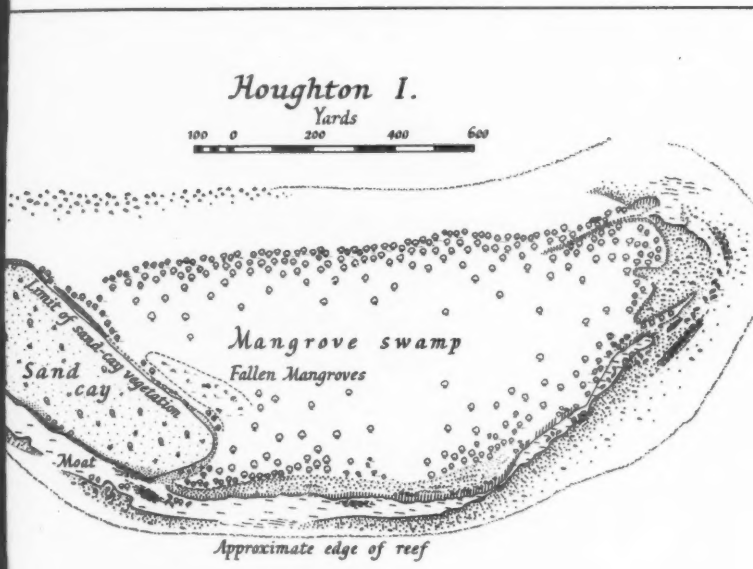


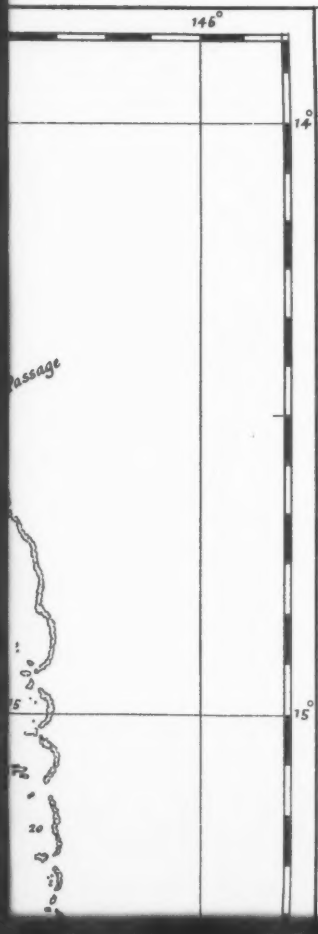
the Royal Geographical Society

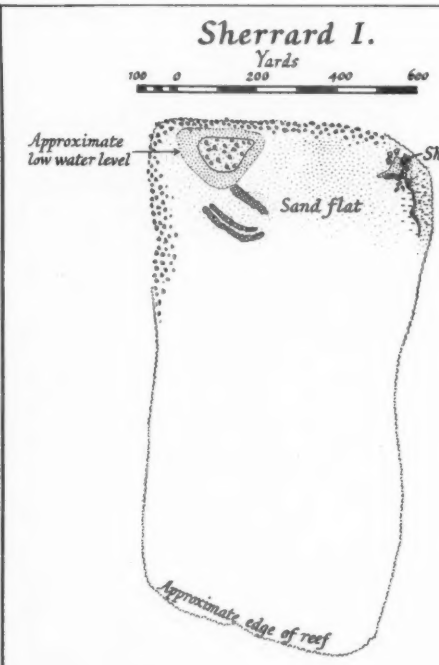
TURKANA PROVINCE
KENYA COLONY
Champion

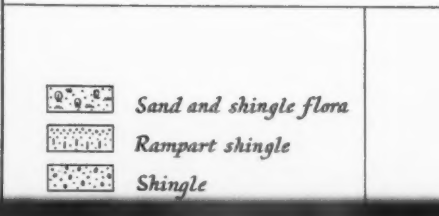
144°
Cape Direction
Chapman I.
Sherrard I.
13°
Night I.
Binstead I.
Lowrie I.
Ellis I.
Fife I.
Hay I.
Wilkie I.
Hannah I.
Burkitt I.
14°
Claremont Pt.
Port Stewart
Dhu(d) Reef
King I.
Flinders Group
Princess Charlotte Bay
QUEEN
144°
Miles
Turtle Group
Torres Str.
Cape York Peninsula
The Direction
Area of map

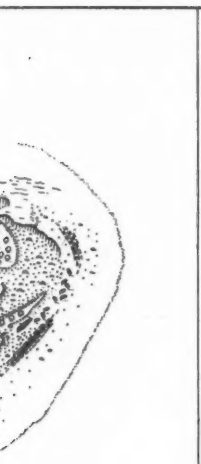

145°
QUEENSLAND COAST
ND ADJACENT REEFS
Soundings in fathoms
13°
100
Limit of sand-cay vegetation
Sand cay
Mest
146°
Melville Pass
King I.
Pipon Is.
C. Melville
Ingram I.
Bewick Is
Beanley Is.
Watson Is
Newton Is.
Morris
Howick I.
Houghton I.
Coquet I.
Cook's Passage
Enn I.
Lizard I.
Turtle Group
Kew(q) Islets
L A N D
145°
C. Flattery
Two Isles
Low Wooded Is.
Three Isles
C. Bedford
CORAL SEA


Houghton I.
Yards
100 0 200 400 600
Limit of sand-cay vegetation
Sand cay
Mangrove swamp
Fallen Mangroves
Moat
Approximate edge of reef


146°
14°
15°
Passage
5
20


Sherrard I.
Yards
100 0 200 400 600
Approximate low water level
Sand flat
Approximate edge of reef


Sand and shingle flora
Rampart shingle
Shingle



I.

00 600

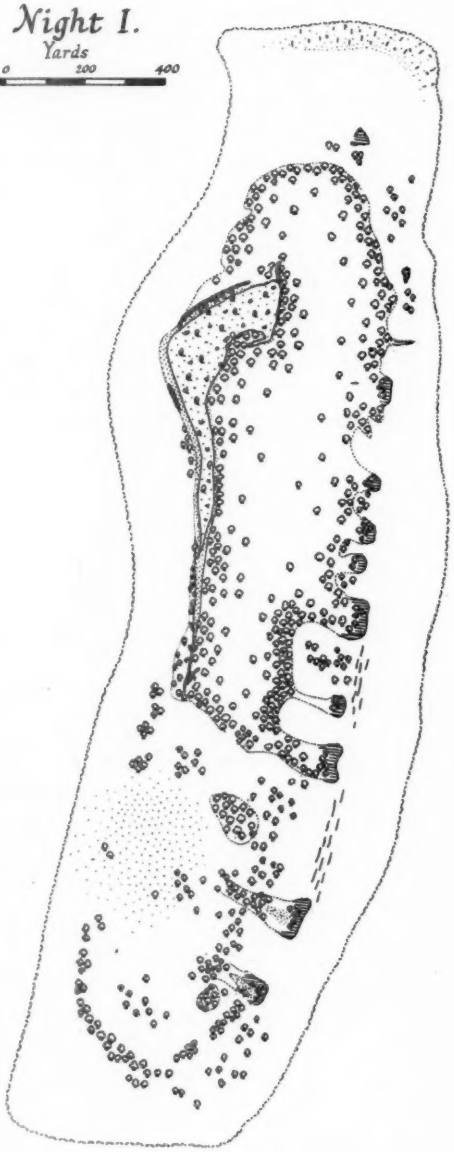
Shingle

lat

Night I.

Yards

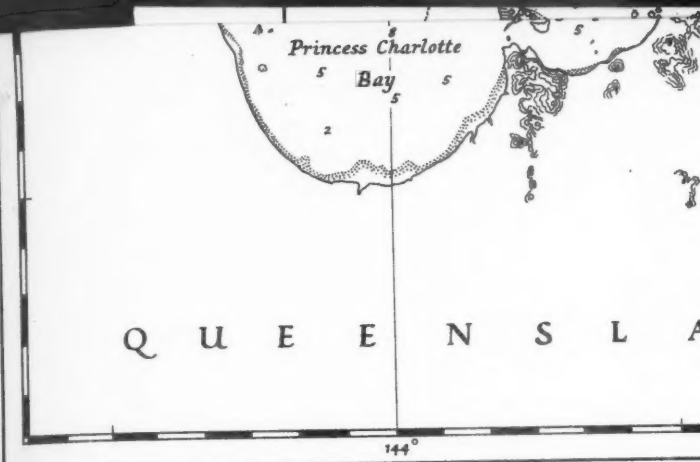
100 0 200 400

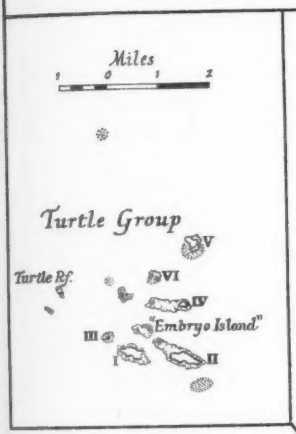


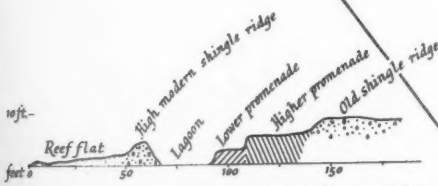
Enn I.

Yards

100 0 200 400 600

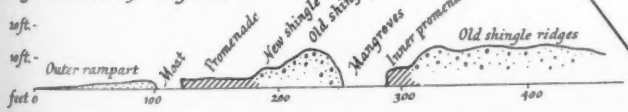






Rough Section of Eastern End of Coquet (shingle) Islet

Rough Section of King Island



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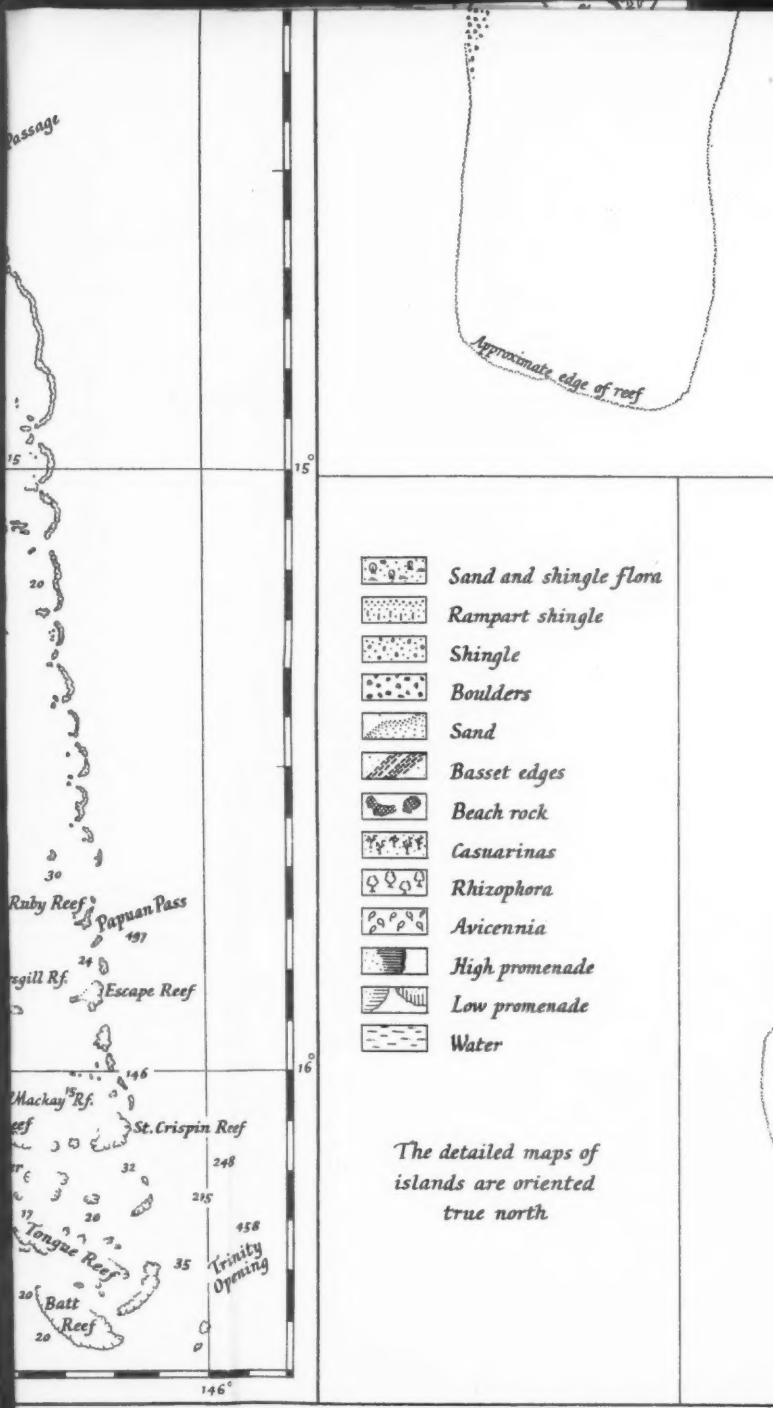

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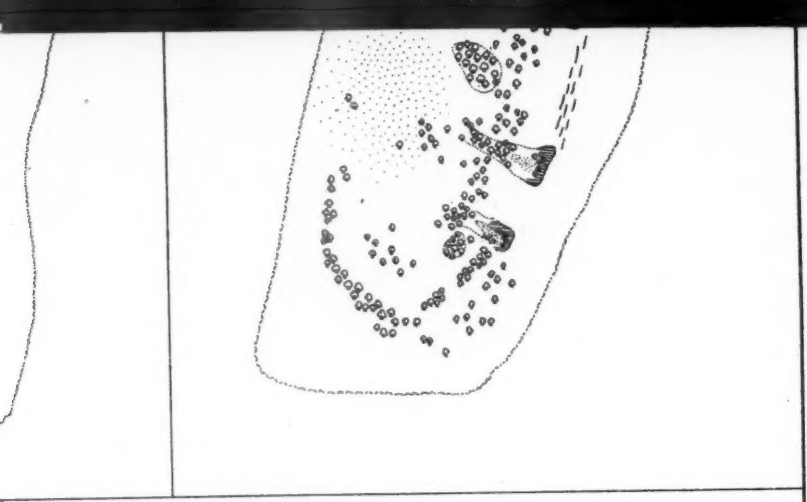

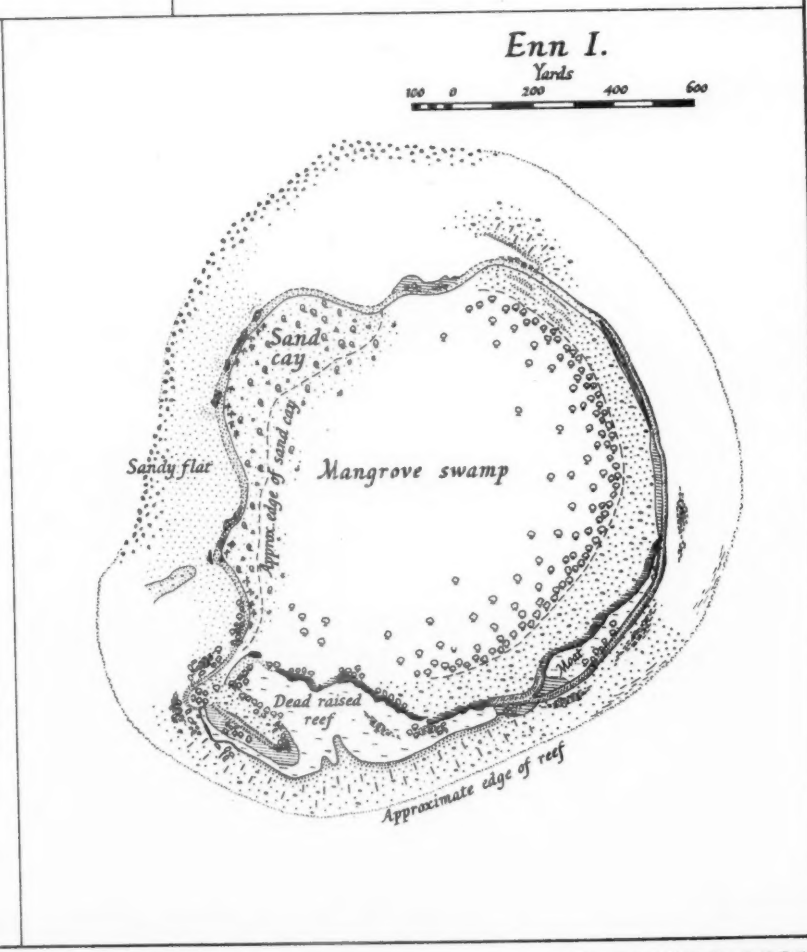

GT BARRIER REEFS
Steers